KNOW IN ADVANCE!

t the moment you were born, gave you a special secret that lets joy peaks of good health, success, ence, insight and luck! In the next onths, you'll have at least 5 such f-the-form days. The trouble is, you know when unless..

Your Kingdom

ss you have found the key to this stupendous secret.

cret has been decoded. The key is hythm. In simple words, all it means your body produces, stores up and es energy in 3 regular cycles ng simultaneously on a continuing

ing Discovery

hythm is Big News in the West although it all started with ilhelm Fliess, a late 19th century practitioner who is reputed to have d the great Freud himself.

's Bio-Rhythm practice takes into nt 3 cycles:

- he 23-day Physical Cycle (energy, trength, endurance, sex, confidence).
- he 28-day Emotion Cycle (moods, ensitivity, creativity).
- he 33-day Mental Cycle (learning bility, logic, memory).

Bio-Rhythm Works!

mber Nadia Comaneci, the 14-year-lympic gymnastic champ? During eriod when she went on to make pic history at Montreal, all her s were in the upswing with the cal Cycle near its peak—and at its the day she won a Gold Medal in neven parallel bars.

ame is true of Mark Spitz, winner Gold Medals at Munich.

irst time Jackie Bouvier met John edy to interview him for the ington Times Herald, her Emotion Mental Cycles were at their respective s. Later on, she went on to marry nd became America's youngest Lady.

Rhythm in Action

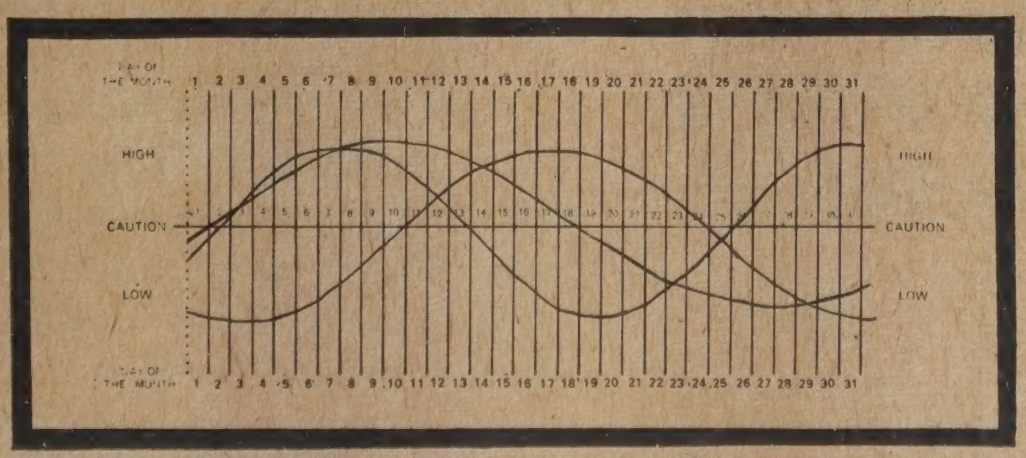
Rhythm is no more a vague theory. ing businesses use it to ensure that employees perform better at jobs:

- ited Airlines
- issair
- unicipal Transit Companies in Zurich witzerland) and Hanover (Germany)
- xi/Bus Companies in Japan.

hospitals chart bio-rhythms of nts in order to decide on the right for surgery!

Bio-Rhythm for Success

you can chart your own Bio-Rhythm y and regularly! Find out your best ... when to take important decisions hen to take chances... and all that need to know to win wealth, ess, happiness, love—and to keep inning. Order your own Mark Hi-Q Rhythm System containing all the ssories you need to chart your R charts including an easy-to-follow uction, available for the first time dia!



Some Testimonials to Biorhythm

More than 5,000 industrial firms use it in accident prevention, says Mel Lyell, safety engineer for the Virginia Department of Highways.

A bus company in Japan, using Biorhythm to schedule its drivers, had no accidents during 4 million kilometers of driving, according to reports in the National Safety Council's Safety Newsletter.

The Tactical Air Command of the United State Air Force conducted an informal study of 59 accidents involving pilot error. In 13 cases, the pilot was in a critical day and in 40 of the cases, the pilot had two or more Biorhythmic cycles in low.

United Airlines keeps a daily check on its 28,000 employees by means of Biorhythm.

On a New York radio show November 11, 1960 George S Thommen said that Clark Gables's biorhythm chart showed that he would have a "critical" day on November 16th. Gable died of a heart attack on November 16th. (Mr. Thommen was foremost in introducing Biorhythm to the United States.)

Published studies by the highly respected National Safety Council and The Guggenheim Safety Institute of Cornell University lend credence to the theory.

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BIO-RHYTHM

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- *Accept or avoid challenges*
- *Go all out or take it easy*
- *Travel or stay home*
- *Seek or avoid new social or emotional involvements*
- *Start anything important involving your business or personal life.*

What is Bio-Rhythm?

A scientific method whereby you can predict your own (or other people's) 'good' or 'bad' days—when you'll be up, when you'll be down, when to go all out, when to take it easy, when to decide, when to put off deciding, etc.

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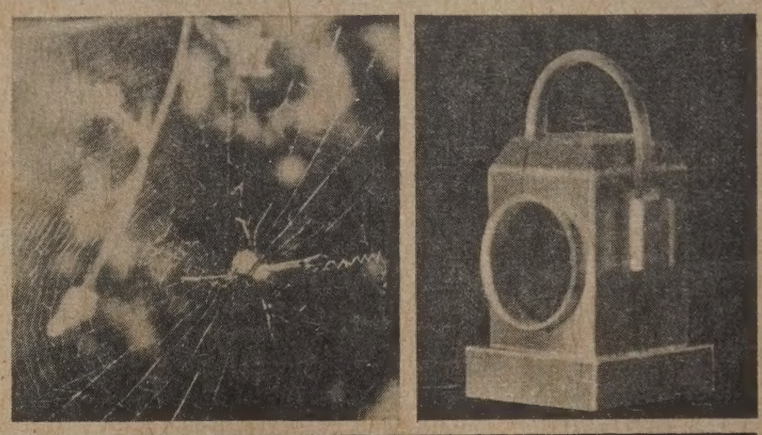


LETTERS

Dairying — who benefits?

By and large, dairy development has benefited only a section of the rural elite who find it very profitable, although many programmes are aimed at helping the small and landless peasant ("Cattle-breeding — does it help the rural poor?" August 1977, p. 13). The landless and poor farmers have no land for growing fodder and grazing cattle, no capital to buy good breeds, no facilities for hygienic milk production and no free veterinary services. True, there are co-operatives which give incentives, bonus and loans in return to regular supply of milk. The co-operatives have shareholders who have invested the minimum amounts. But the policy-making and governing bodies are controlled by the rural elite and the technocrats corner all the profits. Caste politics in employment is also an important factor.

Though the dairy industry has a long history in India, it is totally dependent on western technology from cross-breeding of cows to vaccines and processing and processing equipment like pasteurisers, separators, etc which have to be imported. The industry is capital-intensive and the capital raised in our countryside goes to pay the foreign companies.

The cost of collection, chilling, transportation, processing and distribution in cities and the salaries of technocrats raise the cost of milk considerably. Most of the private agencies do not market milk, but convert it into products like butter, milk powder, ghee and ice-cream, since these are more remunerative.

Eventually, those who profit from dairying are the rural elite, technocrats and middlemen.

ELIAS MARIADASS
Shanti Nagar
Secunderabad 500 017

Statistics in modern scientific research

This refers to Dr. C. Radhakrishna Rao's article on the role of statistics in modern scientific research (December 1977). Significant advances in scientific research were made even before the modern statistical methods were known. Konrad Lorenz, the Nobel Prize winning biologist, deliberately avoided quantitative methods. "The language of nature is more complicated than the language of mathematics", observed Prof. J. B. S. Haldane. Scientific data may not be quantitative, and quantitative data may not be statistical. Unless a scientist can explain something, his statistics have little or no significance. Collection of such statistics reduces a scientist to a mere recorder and breeds reductionism in science. In modern scientific research, statistics is welcome as a friend but not as a guide.

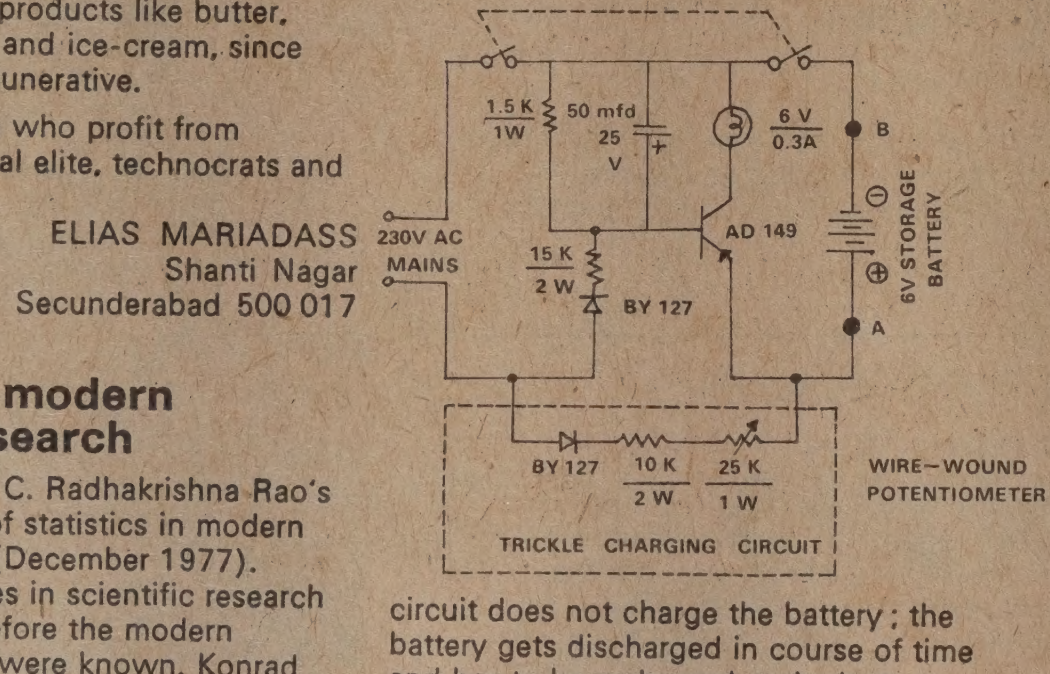
"Statistics must have a purpose", observed Prof. P. C. Mahalanobis. And the 'purpose' lies in the field of study and not in statistics which is merely a technical equipment.

Statistics seeks to take up the role which physics played in the nineteenth century. Putting aside all considerations of limitations and modesty, physics wanted to turn philosophical, and physical knowledge was used to make assertions about nature as a whole. Physics is now returning to its original self-limitations. There are limitations of science and of its methods as well. The mechanistic-materialistic world-view (propagated by Descartes and others) on which the modern scientific movement is based is in crisis. Heisenberg observed: "Many modern creeds which claim that they are, in fact, not dealing with questions of faith, but are based on scientific knowledge, contain inner contradictions and self-deception" (Heisenberg, W., *The Physicist's Conception of Nature*, 1958).

P. C. DASCHAUDHURI
Bio-Science Division
Indian Statistical Institute
203, B. T. Road, Calcutta 700 035

Emergency light

Let me draw your attention to the imperfect functioning of the "Solid State Emergency Light" (You Too Can Do It, April 1975). I have constructed it using a 6-volt storage battery (11 AH EXIDE) and the trickle-charging circuit. The drawback is that the trickle-charging



circuit does not charge the battery; the battery gets discharged in course of time and has to be recharged at the battery service station. The voltage (measured after connecting the unit to the AC mains and removing the battery) at points A and B shown in the diagram is 5·6 volts, which is not sufficient to charge the battery.

R. K. AGRAWAL
C/o Sahu Vishnu Swarup
57-A, "Kesari Singh"
Pilibhit 262 001

Mr. Borkar writes: The circuit incorporates the trickle-charging circuit for small rechargeable batteries. The circuit is perfectly all right. However, there is considerable difference between a trickle charger and a recharger. According to the *Standard Handbook for Electrical Engineers* (Sec. 24-12):

"Trickle charge is a continuous constant charge given to a battery maintain it in a fully charged cond with no external load connected t This may be used for batteries in s or in standby service, where their o is in an emergency such as failure normal power supply. In setting up a trickle charge, a current value of 50 to 100mA/100 AH of battery c is a good trial value. However, the voltage should be checked and cu readjusted until an average voltage 2·15 to 2·17 V/cell is maintained.

Thus, the trickle charger, with the adjustment of trickle-charging curren between 3 and 10 mA, is capable of maintaining small, that is, 3 to 22 AH capacity rechargeable fully charged batteries. The trickle charger cannot recharge a fully discharged or a new battery as the recharging current requ is many times more than the trickle-charging current. Thus, you will have start with a fully charged battery and sure that you don't discharge it fully.

Secondly, the right way to evaluate trickle-charging current is to connect multimeter on milliamp range in series with the battery. The voltmeter metho not the right way as the indication wi depend on the meter sensitivity and t range used. Thus it will show wrong sometimes absurd indications.

A safer pistol

Mr. R. S. Prasad's letter (January 19 suggesting the use of a magnetic ring known strength may be an improveme But after a long period the magnetic power may be decreased and it would difficult to use the firearm immediately Would it not be better, if the digital loc is used? It will only be unlocked when rotation of digit-wheels forms the particular number (say 7 0 0 1). To facilitate night use, radium digits could used.

P. SIK
Sikdarpara, PO Raghuna
District Purulia, West Be

The IMS conference — a few pointers

The 43rd annual conference of the Indian Mathematical Society (IMS) wa held in Aligarh Muslim University from to 27 December 1977. It was, more or l a routine affair consisting of the inaugu function, the presidential address, some invited addresses, two symposia, paper reading sessions, cultural programmes, Since the volunteers were hospitable, arrangements were good, and most of th sessions were well-attended, the conference can be said to be successful the conventional sense. But a few point which show our attitude to science and scientific organisations, do call for attention.

The inaugural function of the conference started with the recital of a f verses from the *Quran*. As the verses we

cited, the English translation was ojected on a screen. A line in it read mewhat like " Believe in God who has eated this world ", etc. Now, why ould an IMS conference begin with ch recitals? Does the IMS, as a national dy of Indian mathematicians, believe in ings like the world being created by od? Such beliefs in religious theories out the material world would amount to e virtual annihilation of the achievements the great mathematicians like Galileo, ho fought against the religious bodies of s time for the establishment of the ientific theories about this material orld.

In contrast, the Vice-Chancellor of the niversity, in his speech, talked quite a lot out the scientific attitude. He also aised (very rightly) the late Sir Syed hmad for his efforts to inculcate the ientific attitude among Indian Muslims.

In his presidential address, Prof. U. N. ngh said : " For a country of India's size, e number of active research athematicians of international standing nd the output of quality research should be ore than it is today. The IMS has to play decisive role in this task. It cannot be xpected of the IMS to provide much of hysical facilities, but certainly the IMS an create an awareness and be an active strument in energising the entire cademic atmosphere." First of all, it is not lear why exactly should India have more athematicians than it has today. Second, ow will the IMS create this awareness and nergise the atmosphere? At least, Prof. ingh's address did not contain any oncrete suggestion, except, perhaps, that f the publication of research monographs y the IMS. But these are not very mportant points. The point we should ealise is that, in the type of society that ve live in, the number of active research athematicians, as that of any other rofessional, depends on the demand in he market, just as the production of any ommodity in the country depends on the emand for it in the market. The number f mathematicians in the country has little o do with the need of the country and still ess with the awareness, energised tmosphere, etc.

A symposium on the teaching of athematics has almost become a ritual in very annual conference. There was ractically nothing new. Nothing was alked about primary or school-level ducation. All the speakers talked about ome technical things about college and niversity education and about a few chemes. The conclusions drawn at the nd were too general — the syllabi should e made up-to-date, the standard of eachers should be raised, the examination system should be reformed and so on. No one spoke on what the IMS should do about any of these things. Instead, the participants simply passed some comments like the IMS should do " something " about it, " something " about that, etc. No symposium is necessary to arrive at such conclusions.

Finally, the general body meeting is supposed to review the activities of the Society during the previous year and decide about future activities. That only one hour was given for the general body meeting in the three-day conference is quite significant. A substantial part of even this one hour was consumed, as usual, by various official reports, and very little time was left for questions, comments and general discussions. The delegates had the same old suggestions — the abstracts of the papers to be read in the conference should be sent to members at least two weeks in advance, the IMS should publish research monographs, it should organise regional level conferences, instructional conferences for young research workers, summer schools, winter schools for teachers, etc. These suggestions are made every year and the talk invariably boils down to lack of funds. And so it was this year. It was suggested that the IMS should approach the various departments of the Union Government, State Governments, Government bodies like the CSIR, UGC, NCERT, universities, research institutions and industrialists for funds. There is nothing new in these suggestions; any one associated with any scientific organisation would think of these ways, and so must have the office-bearers of the IMS. The question is, why have not these steps been taken yet?

I do not suggest that the reason for the present state of affairs lies in the lack of sincerity or efficiency on the part of the office-bearers. The reason is more basic, and it lies in the intrinsic weakness of the IMS. In his presidential address to the 42nd annual conference at Trivandrum, Prof. P. C. Vaidya had pointed out: " The membership of the society at present consists of about 320 life members and almost an equal number of ordinary members." The IMS is too small a body to have any impact on the teaching of mathematics in India. With the present strength, it is also doubtful whether it can play any significant role in shaping mathematical research in India.

S. H. KULKARNI
Research Scholar
Department of Mathematics
Indian Institute of Technology
Powai, Bombay 400 076

Aero-charger for cars?

Miss N. K. Rohini's interesting proposal about aero-chargers for cars (Letters, January 1978) reminds me of an advanced perpetual motion device which I used to dream of when I was about eight years old. It was a motor driving a generator and the latter was to supply the necessary electric power to the motor; we could take electric power from the generator or mechanical power from the motor, as and when we liked. I am now older and wiser.

K. R. D. PRASAD
174, Defence Officers Colony
Madras 600 097

The coconut land

S. R. Amladi (" Let's Get to Know Our Trees ", January 1978) mentions that P. V. Mayuranathan, in a learned analysis, pointed out that the coconut must have originated in the ancient Papuan land. Though this is a controversial topic, many researchers favour the idea that *Cocos nucifera* evolved in its present form on the coral islands in the western Indian Ocean. J. O. Sauer in *Plants and Man on the Seychelles Coast* (University of Wisconsin Press) notes the higher incidence of volunteer coconuts (not planted by man) in the Seychelles compared with other regions of the world. The coconut is, of course, a classic example of an ocean-disperser and Sauer believes that the Seychelles nuts are better adapted to transport by sea. He concludes that the Seychelles must have been one of the most important sites for the evolution of this palm.

NIRMAL KANTILAL SHAH
12, P. Alankar
J. Mehta Road
Bombay 400 006

Need to co-ordinate

Neither the method nor the equipment described in " Drinking water from salt water", (Ideas & Inventions, January 1978) is new. I had seen an exact replica of it way back in 1974 in the Defence Laboratory in Jodhpur, where research on this very topic was being conducted. And my project report for the National Talent Search Examination, for which I was selected in 1975, was the study of the effect of factors like the wind velocity, the angle of glass cover, etc on the output in such a device. The point is, these facts emphasise the need to co-ordinate scientific research in our country to avoid starting from scratch when work is already going on. This will save valuable scientific man-hours, let alone money.

K. CHANDRASEKAR
III B.E. (Mechanical)
Regional Engineering College
Tiruchirapalli 620 015

Wanted : sand samples

This is a request for help from your readers. I am studying the minerology of sands all over the world. I would like to receive samples from India. Samples must be at least 2·0 grams, with information on the geological age and period, and the geological formation they belong to. Could anyone send me a geology map of India?

CARLOS E. GOMEZ RIFAS
Calle Artigas S/u
Los Cerriuos
URUGUAY

No response via "Astro-Response"

I procured a copy of the " Astro-Response System ", which was advertised in your magazine, and applied the methods given therein on a child — and I failed miserably. It did not obey any of my commands.

I am disillusioned. Strangely, you have again spared a full-page for another such advertisement in February. Why not ask the advertisers to process their claims before they publish it?

B. K. ADHYA
S. C. Shome Training Academy
Chinsurah, Hooghly District
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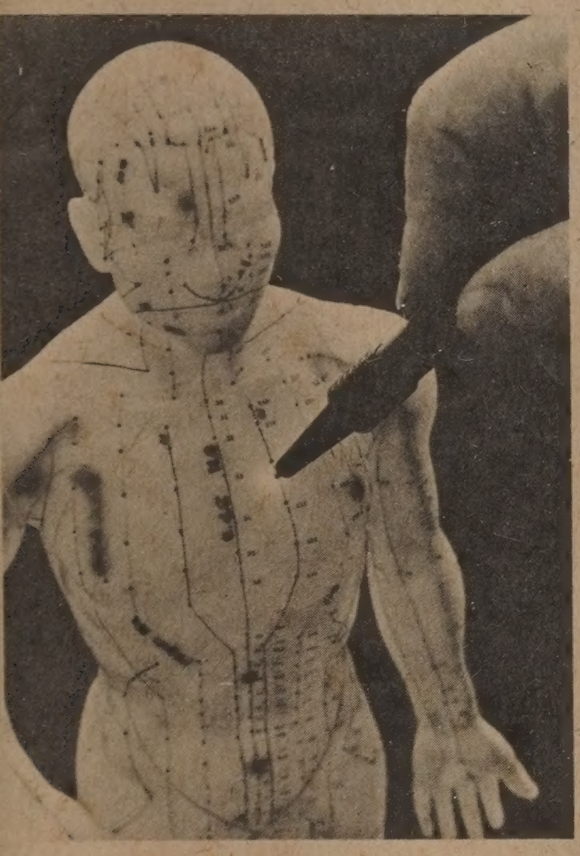
ACUPUNCTURE WITHOUT A PRICK

Now you can do the Chinese trick ithout using needles. Lasers of a rtain wavelength (at the red end of e spectrum) can penetrate human in. Depending on the type of skin, e penetration varies between three d 10 mm. Siemens has developed helium-neon laser tube that can



enetrate deep even at very low power. his paves the way for painless and ntiseptic acupuncture. The radia- ons (wavelength 632 nanometres) re conducted through a glass fibre onveyor to a handpiece (the pen-like bject in the photo) which delivers he beam to the desired spot. This nethod can be used on primary pain ocations as well as on irritating and eflex zones.

The photograph shows a model narked with acupuncture points along he latitudes defined by the Yin-Yang rinciples.

DOCS, PATIENTS AND HEPATITIS

Hepatitis B spreads through blood and blood products of the infected persons (SCIENCE TODAY, August 1977, p. 18). t is recognised as an occupational risk or physicians. The risk begins during nternship and rises as the practice period grows. On the whole, a doctor is 5·25 times more likely to catch the disease than the layman.

According to a survey report in *JAMA (Journal of the American Medical Association)*, surgeons and pathologists are in the highest risk group because of their constant exposure to infective material.

In a two-year (1975-76) nation-wide survey, Alexander E. Denis and colleagues of the Hepatitis Laboratories Division, US Department of Health, Education and Welfare, Phoenix, Arizona (USA), checked 1,192 scientists attending three American Medical Association meetings. They found more than 25 per cent cases of infection among surgeons and pathologists. Only 31 per cent of antibody-positive doctors recalled having the disease. This means that the rest of the cases had either been wrongly diagnosed or were asymptomatic. According to the report, the risk began at internship and rose during practice while the risk of other forms of hepatitis remained unchanged. Some doctors and dentists overreacted to these findings and wanted their patients to be screened. Patients, on the other hand, are afraid the doctor will give them a disease instead of curing them.

FRUIT JUICE FROM RICE

A Japanese scientist, Masonori Shinozaki, of the Toho Fermentation Research Institute, Chuohononachi Utsunomiya, has developed a method of converting rice into a drink with a taste between that of syrup of canned peach and that of pineapples.

Japan has a surplus of rice and they think this would be a good use for it. The juice is obtained by fermenting boiled rice with saccharifying fungi. The amber-coloured drink contains 16 per cent glucose, four per cent protein and also other organic acids, esters and aminoacids. Shinozaki says, it is a very easily absorbable juice and would be an ideal drink for children. He also said that the fungi could be made available in powder form so that consumers could brew the drink at home. The solid residue after the juice was removed could be used as animal feed.

BAKING SODA TO "RAISE" KIDS

The common household chemical, baking soda, can reverse dwarfing in children and raise them to normal height. Children suffering from the rare kidney disease, renal tubular acidosis (RTA), are stunted in growth because of excess of acid in their body; the kidney fails to rid the blood of acid. The best way to cure the disease would be to neutralise the acid, reasoned researchers at the California Medical Centre, San Francisco, USA. In a 3-year study, Elizabeth McSherry and Curtis Morris found baking soda did the trick.

They report their findings in the February issue of the *Journal of Chemical Investigation*. Six affected dwarf children grew to normal size within three years, their rate of growth increasing two- to threefold. The baking soda treatment had been tried before but without success. The California scientists found that the dosage needed for children was high — three to four times more than that needed to neutralise the backed-up acid. The dose varied with individuals; it increased as the children grew. Once they reach adulthood, the dose is decreased and will probably be kept at a limited level throughout life.

McSherry and Curtis found that baking soda therapy could also act as a dwarfness preventive: two affected infants grew at a normal rate when given baking soda therapy. The only drawback of this treatment is a slight distension of the stomach.

GOLD-PLATE YOUR WINDOWS

The price of gold may be up, but using it to coat your windows will cut your fuel costs. Gold added to glass increases its reflectivity to heat and glare and thus affects it insulation value. According to the Gold Institute, it also improves the appearance of the building; several office buildings in the US, Canada and Europe are using gold glass. The energy saving — heating in winter and cooling in summer—soon makes up for the initial extra cost. Gold glass windows cost about three times as much as the non-insulated windows. Depending on the method used for coating, about 30 g of gold covers about 40 to 90 sq metres of glass. In Dallas, Texas, the developers have used gold glass for their office complex. They claim it saves them 31,400 kilowatt-hours on a summer's day.

EARTHQUAKES AND VOLCANOES—A BALANCE

Last year, there was an increased number of volcanic eruptions — more than 35 all over the world. In 1976, there had been only 10. According to the United States Geological Survey, the increase is actually a return to the normal level of two or three dozens per year. The number and intensity of earthquakes, on the other hand, dropped last year. In the year 1976, about 700,000 people died in earthquakes, most of them in China. There had been 50 quakes registering more than 6·5 on the Ritcher scale, compared to 36 in 1977. In 1977, the number of deaths was 2,800; the annual average generally is around 10,000.

NON-DEFLATABLE TYRES

With such tyres you wouldn't get a flat even when punctured. The trick is to fill the tyre with extremely light porous particles. The designer, Michelin of France, explains how it works. The particles are one to eight mm in diameter and are doused with a lubricant like polypropylene glycol or polyethylene. They may fill the entire tyre or may be contained in a thick plastic bag that ruptures following a puncture or blow-out. When the tyre is punctured, the air rushes out at the rift. The particles are sucked into the rift. And the particles, Michelin specifies, must be made of

silicone or any polymer capable of withstanding high pressure, so that even if all the air is lost, the tyre remains inflated by them.

HOW DO THE HENS FEEL . . .

. . . about their life in the battery? From the human point of view, life in the battery cage has been regarded as cruel. Marion Dawkins of Oxford's Zoology Department decided to ask the hens what they felt.

She used two sets of hens: one set was raised in a pen in the garden and the other was battery-raised. She posed a straight preference test in which the birds were trained in a T-maze with each arm leading to one environment.

What she found was not so surprising after all. Though, initially, the birds opted to go into the environment they were used to, the battery-bred hens shunned the battery after they had once tasted outdoor life. About 30 per cent of them could be lured to the cage with food, but given other choices, like being alone in the open or with companions in the cage, they all preferred to be outside. As for the garden-raised hens, they didn't once care to look into the battery cage.

SAFER INSECTICIDES

With the help of a computer, Australian Commonwealth Scientific and Industrial Organization's (CSIRO) scientists have developed a new range of 18 biodegradable insecticides. Known as insecticidal esters, the new compounds are among the most potent insecticides known to science. Yet massive doses of one of them injected into a lab mouse showed no ill-effects.

The chemicals, active against a wide range of insects including housefly, mosquitoes, beetles and granary weevils are cheaper to produce. Their potency can be enhanced by the addition of other chemicals, called synergists, which act by suppressing the insects' natural defences. Most of these 18 new compounds also exhibit a strong repellent effect against some pests. This action can be used to prevent the insects from laying eggs in their specific niches.

If long-term tests confirm they are safe and effective, the product could be marketed by 1980.

FIGHT IMMIGRATION —WITH A SONG

Keep out undesirables and prevent crowding — all with a song? So says J. Krebs from his study of the great tit.

More songs were more effective in scaring intruders off the great tit's territory

Courtesy: New Scientist *Photo:* Eric Hosking

(*Nature*, **272**, p. 539). Normally, in birds, the simple song should suffice to attract the mate and defend territory. But most birds have a repertoire of at least four songs. Unlike the canary, which woos the female with musical variation to combat competition, the great tit launches into song after the mating season is over.

Starting from the basic premise that the great tit's repertoire is related to territorial defence, it was discovered that intruders were effectively debarred by playing the song through loudspeakers. The woods around Oxford were divided into three areas — a 'control' area with no loudspeakers; a single song area where only one song was played through loudspeakers from dawn to dusk at regular intervals, and the "repertoire area" where the full range of the great tit's song was played. The results showed that control area was the first preferenc the newcomers. The repertoire area the last to be settled.

The repertoire acts as a deterrent, to the "Beau Geste" effect, say Oxford scientists. Reproductive suc is negatively correlated with densit settlement. The large variety of s deceives potential immigrants into th ing that the habitat is already o crowded.

YEAST MODEL FOR GENETIC ENGINEERS

Escherichia coli, the common bacter found in the human gut, has been choice model of most recombinant D studies. The fact that it is found in intestines makes it all the more danger a runaway mutant could mean a disas

Now a group of scientists at Cor University, USA, have successfully in duced bacterial DNA into baker's ye By doing this, Gerald Fink and co-worl have done just the reverse of what o biologists have done so far; they tra ferred the gene of a lower organism a higher organism. The yeast cell used new genes to overcome a deficier Yeasts being nucleated organisms more akin to animals than are the bacte They aren't pathogenic to man and t do not live inside human beings. these go to make them more suita experiments models.

Fink and his co-workers selected yeast strain that lacked the ability make the amino acid, leucine, spliced into it the bacterial gene for leuc production. The leucine gene was a successfully transferred to the offspr like the yeast's own genes. Laborat gene transfer in yeasts hasn't been easy job except by standard sex processes. Fink and colleagues usec snail enzyme to encourage the yeast take up the bacterial DNA. (This enzy is used as a cell wall solvent in bota experiments.)

The only hitch in this experiment v that the recombinant DNA could not traced: none of the bacterial genes ma any product that could be easily identif — even in the bacteria.

FOOLED BY THE EYE SHADOW

A 16-year old girl suffering from acu headaches was diagnosed as a case severe stress. But at the Keesler Airfor Hospital in the USA where she went t treatment, doctors found bilateral curv linear calcification in the roentgenogra of the eyes. Blood and urine tests ga no clue to the cause of the conditio Meanwhile one of the doctors notic the patient's heavy make-up. Roentgen grams taken after removal of the make-u showed no calcification, which mea the eye shadow was radio-opaqu (When the eyes are open, the fo accentuates the cosmetic in a narro curvilinear course.)

TESTING THE OBLIQUE WING

This is the National Aeronautics and Space Administration research aircraft that will test the pivoting oblique wing concept. With a wing span of about eight metres and overall body length of about 10 metres, the light-weight manned craft will be powered by two 202 lb (about 100 kg) thrust Microturbo 18-046 turbojet engines. The primary investigations will go into the handling qualities with various wing angles up to 150 knots. The picture shows the wing double-exposed: straight for low speeds and oblique for high speeds. The aircraft is scheduled for delivery in November this year.

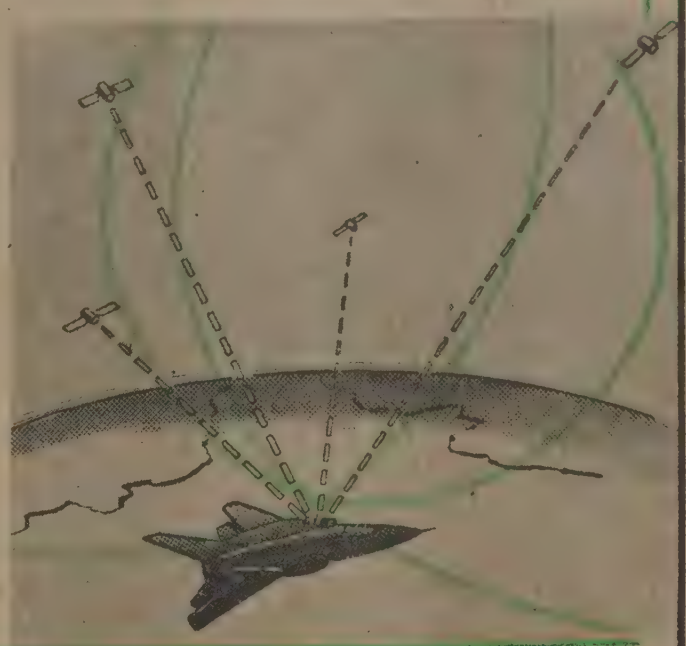
24 STARS FOR STEERING YOUR SHIP

A new satellite navigational system, involving 24 satellites, is expected to be in operation in 1984. Called 'Navstar', it will have a horizontal accuracy of five metres and a vertical accuracy of seven metres and can measure velocity, in three dimensions, to about five centimetres/sec. Designed jointly by the US Army and Navy, the system will have obvious applications in weapons delivery, particularly for cruise missiles and remotely piloted vehicles; there are plans to use them for mid-course guidance for nuclear missiles.

When fully operational, the system will use 24 satellites with 12-hour periods, dispersed in three planes of 8 satellites, each plane being inclined at 63° to the equator. Thus, at least four, and often more, Navstars will be continually in view. If signals are received from three satellites simultaneously, then by timing the arrival of each signal, it is possible (since the velocity of radio waves is known) to calculate the position of the signal receiver. The measured distances effectively define a sphere around each satellite and the position of the receiver is at the intersection of the three spheres (see sketch at right). Each Navstar will carry a caesium clock to ensure the accurate synchronising of the signals of all three satellites, which is essential for accuracy.

With the existing Transit navigational system, which uses five satellites, it is possible to have an accuracy of 50 metres or so. However, with Transit, satellite passes are intermittent — about every 40 minutes or so in temperate latitudes, but an hour apart in equatorial regions. Accuracy is greatly reduced unless the ship's velocity is accurately known.

Though developed for weapons delivery, the precision of Navstar is such that civil receivers for simple two-dimensional jobs like harbour navigation are already being planned.



r. W. F. Forman and colleagues of the Force hospital analysed 25 types of shadows available in the market. They roentgenograms with the make-up a thin sheet of paper. Four per cent of products were radio-opaque and thus ld lead to similar wrong diagnosis.

HE MISSING RINGS

ranus, it was found last March, five rings; from the planet outwards are known as Alpha, Beta, Gamma, a and Epsilon. However, in a study of planet by stellar occultation on ember 23, none of the rings were n. Perhaps, the glare of the near-dawn ng of the event affected visibility on outbound side. But, says Robert is of Lowell Observatory, Arizona, A, the occultation should have been ble on the inbound side. Where could rings have vanished? According to is, "If Alpha and Beta were present, were much shallower than they e in March" and perhaps the time olution of 0·05 second was not ugh to show them up.

here might be another reason why the gs weren't seen. The rings may not be formly thick all around, suggest some earchers. The varying concentration of particles, they say, could be attributed "density waves". The reason for the den- waves they haven't explained, though.

EWER MARRIED EN GET ULCERS

Prof. Carol Buck of the Department Epidemiology and Preventive Medie, University of Western Ontario, nada, reports (in the *Journal of psocial Science*, **10**, p. 35) that rriage is good for men. Married men ve lower chances of death from peptic er than single men. Perhaps economic tors contribute to this; there are re bachelors and also more deaths due peptic ulcers in the lower social scale. w does marriage help, anyway? Professor Buck says, either women select men in better health for husbands or it is their care that keeps their mate's ulcers away. Perhaps both factors have some influence.

MEDICATED CHEWING GUM

Feeling low? How about a stick of chewing gum? Andrew Weil of Harvard University, USA, is planning to develop a coca-based chewing gum which could be a fast-acting anti-depressant or be a stimulant like coffee and a remedy for gastrointestinal distress. Weil's inspiration comes from the coca leaf, chewing Indians of South America. Coca, says Weil, has about 0·5 per cent cocaine and 14 related drugs. He also found that leaves selected for chewing were quite nutritive: they contain large amounts of calcium, iron, phosphorus, riboflavin and vitamins A and E.

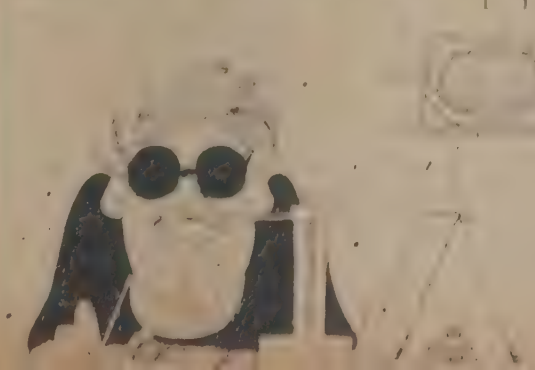
HANDICAPPED PERSONS IN SCIENCE

During the last two or three years, two major scientific organisations in the USA, the American Association for the Advancement of Science (AAAS) and the National Science Foundation (NSF) have been trying to identify the problems of handicapped persons in science. The AAAS has collected the names of 500 scientists who were willing to be identified as handicapped, according to a report in *Chemical and Engineering News*, 23 January 1978, p. 25.

Perhaps two of the more prominent examples of persons who have become eminent in science despite a disability are Dr. Stephen Hawking, a theoretical physicist who is a quadriplegic, and Sir John Cornforth, a chemistry Nobel Laureate, who is totally deaf because of otosclerosis (a condition caused by bone growth in the middle ear). Ironically, Cornforth's affliction was largely responsible for his deciding on a career in science; he had a good chemistry teacher who on learning that Cornforth would become deaf, persuaded him to take up chemistry as a profession. Cornforth feels that in science there are so many non-verbal languages — those of molecular structure, stereochemistry and mathematics — that a deaf person isn't handicapped at all.

One reason for the paucity of handicapped persons in science, the AAAS found, is that many handicapped students are either exempted from science programmes or are segregated into special schools that often don't have any science programmes. Its programme on the Handicapped in Science, the most comprehensive of such efforts by professional societies, attempts to identify the problems of handicapped scientists, to provide them assistance and to improve education in science for the handicapped.

Usually blind students are excused from laboratories because they can't "read" the instruments. One experimental programme run by the NSF is to modify standard laboratory equipment for use by the blind: for instance, a balance that gives an audible tone that varies in pitch, telling the student whether the weight in one pan is being balanced by the weight in the other.



IN SEARCH OF TOMORROW'S CRISES

TER SCHWARTZ, PETER J. TEIGE,
WILLS W. HARMAN

roup of social researchers in California set out to try to identify problems that may become critical in the years ahead. The archers developed eight different techniques for bagging their ive quarry. When the hunt was over, they had discovered 41 ises of tomorrow". A list of the 41 crises follows this article

'N recent years, we have faced an energy crisis, an urban crisis, a food crisis, and many other crises. In each instance, significant onses came only after a manage- problem had developed into a sive crisis. If the pace of social nge continues to quicken, we can ect that we shall see crisis mount crisis until we are overwhelmed. only alternative is to identify blems before they reach crisis portions so that appropriate action be taken.

'o help develop an early-warning em for future societal problems, we he Center for the Study of Social icy recently carried out a series of lies under a grant from the US ional Science Foundation. The lies aimed specifically at providing dance for the President's Science visor, but the results are relevant to almost anyone concerned with developing an early-warning system. Our Center, which is a branch of SRI International (formerly Stanford Research Institute) in Menlo Park, California, specialises in assisting government and business leaders to formulate policies that will both address current needs and contribute toward a workable, high-quality future.

Our project sought to develop a set of techniques for identifying and assessing national or international-scale problems which are not now widely recognised but could become major societal crises in the coming decades. The emphasis was on problems that arise in association with the advance of science and technology, or that have potential scientific or technological solutions. Because of the technological nature of modern society, this includes — at least in some way — most current as well as future problems.

Our search for problems began with the development of a systematic problem-search strategy designed to uncover the type of problem we were looking for. The conventional approach to problem assessment has been to rely on the foresight of individual scientists and technologists both inside and outside the government. Such a process is not likely to uncover problems of a new kind, partly because individuals who have gained sufficient reputation to make their warnings of emergent problems credible have developed their reputations by significant achievements in a limited field, such as a particular discipline or industry. They may see problems in their own or related fields, but their specialisation may hinder them from uncovering problems outside their area of expertise.

The purpose, therefore, of being systematic is to avoid bias in the process of being relevant, and to help ensure that we are uncovering problems that lie beyond the domains of competence or interest of the researchers. A systematic approach, however, should not be mistaken for scientific rigour where none is possible. Nor is it a means of ensuring comprehensiveness: the universe of potential problems is both too large and too obscure for that kind of promise.

The substantive goal of the project was to compile and analyse a set of specific societal problems that might arise in the next several decades. The "ideal" problem was one that is not currently receiving adequate attention relative to its potential as a *future* societal crisis. In all, we identified 41 future problems (see list accompanying this article) which we thought were representative of the more critical problems that society will face in the years ahead.

Besides identifying specific future problems we also learned some important things about how to search for obscure, emerging problems. Our experience led us to conclude that it is essential to devise a number of strategies for problem identification. Each of the different strategies tends to uncover different types of problems. Any single approach contains inherent biases that will reveal some problems but completely overlook others. Our attempt was less than comprehensive, partly because we tried to assess the feasibility and utility of a variety of approaches. A more extensive attempt to use these and other strategies might yield more comprehensive results.

We also found that what is seen as a problem is a function of perspective. From a reductionist scientific perspective, for example, systemic problems are not seen as meaningful. Even with identical overt objectives, the interpretation of the nature of a problem can be dramatically different. Furthermore, understanding the full nature of a problem requires accepting the validity of significantly different interpretations based on a variety of different perspectives. This is true of all problems, at least to some extent, but is of special significance when considering future problems.

New problems may often be found in the junctures and overlaps between old problems. The new problems will not be found in the current crisis gripping national or international attention, but may be discovered by looking for the long-term consequences of that momentary crisis.

New kind of problem

After examining a large and diverse sample of future problems, we reached some significant general conclusions about the changing nature of societal problems. It appears that the problems of the future will be fundamentally different in character from those we have dealt with successfully in the past. Whereas most of human history has focused on our solving the problems of the world as we found it, the critical problems of the future will involve dealing with the problems of the world as we have made it. Indeed, it appears to be the very success that mankind has had in dealing with the former kind of problem that has led to the latter.

Perhaps the most important characteristic of this emerging kind of problem is its systemic quality. We can no longer think of problems in isolation, or look for permanent solutions. Each problem is only an aspect of a much larger system, and is thus closely linked to many other problems. To attempt to " solve " such a problem in the conventional sense often results in making other related problems worse. Therefore, a successful mode of response must be based on an awareness of the system of problem interaction. In general, such a response would be the outgrowth of multiple interpretations of the problem and would involve a continuous process of experimental adaptation and internal adjustment.

A multiple search strategy

Trying to uncover emergent problems is more difficult than might seem. This is particularly true for problems which have not received much attention. Since we live in a time of elaborate scientific-bureaucratic apparatus and multiple crises, a relatively large number of problems are already receiving attention. Furthermore, during the past decade there have been a number of serious attempts to prepare lists of major problems. Reference to them would not and did not help in uncovering potential " surprises". (That is not to say, of course, that all the problems on those lists have either been solved or are even being seriously attended to.)

In devising a strategy to find future problems, we tried, of course, to define the term " future problem ". A traditional definition of a problem as " the gap between what is expected and what is desired " is not very useful when both societal directions and goals are uncertain. After considering a number of different definitio decided that a precise definit impossible. In very pragmatic a condition is a problem if some some group labels it a problem.

Another aspect of future probl the great diversity of interpret that might be given to a single blem situation. The process of me diagnosis is a good analogy fo different types of interpretation might be given for a single pro In medicine, more than one pretation of a problem is com and different interpretations le different treatments. Which inte tation of a medical problem is a ted depends partly on the perspe of the diagnostician, and not jus observed symptoms and test re A diagnosis is based on an iter process in which a number of diff interpretations are explored.

We had to be sensitive to si yet more ambiguous interpret in devising our search strateg societal problems. We also neede structure our search strategy so th took in a diversity of problem would have been impossible to pile a list of *all* future problems, we wanted a diverse sample of blems so that we would have indications of the larger com system of problems.

We quickly discovered that no s technique for identifying proble adequate. We, therefore, devised different strategies intended to cover new problems (see box). the strategies worked to some ex — that is, they all uncovered at a few new problems — but t were important differences in results.

One way to assess the effective of a strategy is to note how man the problems that it revealed en up on the final list of 41 prob selected for consideration. A com hensive literature survey identi over 1,000 problems. Only 20 these made the final list, but no o single strategy identified as m problems on the final list. In contr our examination of trend disconti ties identified less than 10 proble but nearly all of those were inclu in the final list.

After compiling and evaluatin large number of future problems, found that *patterns of related prob* appeared far more significant t individual problems, partly beca individual problems cannot be sol in isolation, since " everything c nects to everything else ". In estingly — and somewhat parad cally — the pattern may be m tractable than its components. individual problems that seem alm

PROBLEM SEARCH STRATEGIES

1. **Problem lists** — Review existing lists of problems from the literature of problem definition.
2. **Alternative futures** — Review futures research literature to identify problems that arise in the context of specific alternative futures.
3. **Science fiction** — Review science fiction to identify problems that have been identified by this form of subjective anticipation.
4. **Opinion surveys** — Survey key persons from the SRI staff and scientific community to identify future problems that might be anticipated from the perspective of specialised discipline areas.
5. **Cross-paradigm analysis** — Survey alternative societal paradigms to identify problems that might appear clearly in one paradigm and be overlooked in another. (A *paradigm* is a " model " or conceptualisation of a situation.)
6. **Trend discontinuities** — Examine key societal trends to find trend discontinuities forced by absurdities that would appear if the trends were to continue.
7. **Problem level analysis** — Compare alternative interpretations at different levels of societal structure for problems that have been identified as serious and possibly persistent, with the purpose of identifying new manifestations of the problem area that might emerge in the future..
8. **Missed opportunities** — Search for significant opportunities for technological or social innovation that, because of characteristics of the current political or social climate, might be exploited.

rwhelming when viewed inde-
dently look more amenable to the
l of understanding that leads to
ntual resolution when they are
en as part of an integrated pattern.

n the past, science and technology
e proved strikingly successful in
ling with a wide variety of society's
blems — so much so that a wide-
ead faith arose in the ability of tech-
ogy to solve problems. Only re-
tly have we been forced by events
the humbling realisation that an
portant class of problems does not
ld easily to a "technological fix".
ese are the problems that are often
roduced with the phrase, "If they
put a man on the Moon, why
n't they. . . ."

f the problems identified in this
ject are typical of these refractory
blems, we can note a few of their
aracteristics: (1) These problems
d to arise as the result of continu-
past trends interacting in new
ys, or approaching some kind of
herent limits, or both. (2) The pro-
ms are systemic in nature, involv-
diverse social institutions, sectors,
d strata, and impinging on various
blics in a widespread and pervasive
nner. As a result, the problems
nfront a dispersed and largely
co-ordinated set of decision-makers
th varied interests and approaches.
The problems significantly involve
itudes, values and beliefs, and
e typically viewed from a wide
nge of perspectives.

Our technological society has been
rticularly successful at solving prob-
ms and exploiting opportunities in
eas such as:

- Agricultural and industrial pro-
ctivity.
- Communication and knowledge
ssemination.
- Transportation.
- Public health (sanitation, control
infectious disease).
- Synthetics (food, fibre, cleansing
gents, building materials, industrial
astics, etc).
- New tools for services and knowl-
dge industries (photography and
pying processes, computers and
ata processing).
- Military systems.
- Geological, oceanic and space
xploration.

rends that cause problems

Most of the future
roblems that we identified appear to
rise from or are associated with such
ontemporary trends as:

- The increasing environmental
mpact of human activities.

Problems 7 and 9

- The increasing rate of depletion of non-renewable resources.
- The increasing gap between rich and poor populations.
- The movement toward a single-world economy, with closely linked worldwide economic institutions.
- The increasing subordination of the economic function to the political order.
- The decreasing importance of private property.
- The increasing dependence of the individual on technology for satisfaction of his needs.
- Increasing homogenisation, decreasing cultural diversity.
- Industrialisation of practically all human activities — goods production, services, and ultimately organic processes (for example, animal husbandry, health care) and humane activities (for example, recreation, education).
- The intensifying search for appropriate individual and societal goods.
- Rising entitlement claims (for example, individual risk insurance, social services).
- Increasing demands for self-determination and for citizen participation in land-use, environment-affecting, scientific-technological decisions.
- Increasing isolation from nature, removal from natural processes.
- Innovation stimulated less by real needs, more by growth imperatives.
- Increasing unemployment and underemployment.
- Declining productivity of capital.
- Increasing need for technology guidance, regulation and control.

Worth noting is the extent to which these trends are associated with the previous list of success areas. The trends that will lead to future problems appear to be, at least partially, consequences of or reactions to our technological successes. In other words, while science and technology

throughout most of the past two centuries have focused on the challenges and limitations of man's *natural* environment, their future role may lie much more in dealing with the consequences of his *technological* environment.

Let us consider the problem of scarcity as an example. The contemporary problems of scarcity are essentially different from the historic problem. Man has always faced the necessity of obtaining adequate food, shelter, clothing, implements, means of mobility and communication, etc, and the typical solution to these scarcity problems has been technological. The "new scarcity" is a different sort: essentially it arises from the demands of technology — the resources and adjustments that it requires — and from the widespread modification of the environment by technology. Thus, scarcity of fossil fuels as well as the scarcity of waste-absorbing capacity in the physical environment arise from the voracious demands of technologically advanced individual lifestyles and industrialised patterns. Many regions are approaching the limits of their natural fresh water supplies, due to the heavy demands of urbanisation, industry and irrigation. Farm land seems plentiful only because its productivity is kept high by fossil fuels; a serious future shortage of farmland may be anticipated due to encroachments by urbanisation and highways, increasing demand for forest products and biomass for fuel, changed dietary habits requiring far more grain per capita, inadequate land husbandry, and escalating world food needs. In numerous ways we are approaching the limits of resilience of natural eco-systems. The resolution of this "new scarcity" problem may not be simply more of the same sort of responses that brought it about; instead, a solution must involve a change in the form and mix of technology and social institutions as well as perhaps limitations on some human activities.

The scarcity focus also illustrates the interrelatedness and systematic nature of modern problems. The scarcity could be alleviated by reduced consumption, longer lasting goods, planned recycling, reduced fashion change, elimination of deliberate obsolescence, and an ethic of frugality. But if these measures were adopted suddenly and without complementary measures in other sectors, they could have a ruinous impact on the economy and exacerbate an already serious unemployment problem. In other words, the apparent trade-off between scarcity aspects and unemployment aspects is disadvantageous and growing worse. A similar statement could be made with regard to the trade-off between the need for imported energy and the need for a favourable balance of payments. The water needed to develop coal and shale in the western US is also needed for agriculture. Trade-offs are nothing new, of course, but it is characteristic of systemic problems that the apparent trade-offs tend to become more serious and harder to make as time goes on.

Problems without "solutions"

Dealing with a systemic problem is best viewed as an internal adjustment procedure in an ongoing, dynamic process. There is no one-time "solution" to the problem. Instead, an assessment is made, an intervention is implemented, the system is monitored to examine whether the intervention accomplished what had been aimed for, and the whole process is endlessly repeated.

By "intervention" we mean a broad class of actions capable of ameliorating the problem. Examples would include a large technological project, a new commercial product or service, a piece of legislation, a set of social incentives, or a policy capa of inducing behaviour change.

The various steps in the interv tion process are carried out conti ously by scientists, analysts, bure crats, politicians, and various part the public in a relatively unco-ordi ted manner. Some problems satisfactorily resolved by technologi approaches, including both physi and social technologies (that is, vari forms of institutional and policy novations); other problems requ some sort of social evolution; s others defy satisfactory resoluti until the perception of the proble changes. For example, problems the aging are typically dealt with developing new medical technolog and by providing various kinds services, but another approach is change social institutions so that the is less pressure to cast out perso at a fixed retirement age. Urb renewal was a technological respon to a problem that failed to solve t problem: some sort of evolution social institutions was needed instea A problem now getting much atte tion is the dilemma posed by t need for productivity and econom growth: higher productivity tends

MEDICAL PROBLEMS vs SOCIAL PROBLEMS

Types of Interpretation of Medical Problems	Corresponding Interpretation of Social Problems
Injury	Catastrophe (eg. natural disaster)
Organ malfunction	Subsystem breakdown or inadequate functioning
Symptoms needing temporary alleviation (perhaps while a more fundamental problem is identified and addressed)	Symptoms needing temporary alleviation (eg. drug abuse, social dissent, crime in the streets)
Disease syndrome interpreted as caused by bacillus, virus, etc	Systemic problem interpreted as caused by specific causal agents (eg. energy problem "caused" by OPEC)
Disease syndrome interpreted as caused by lowered resistance, failure of immunity system	Systemic problem interpreted as caused by fundamental failure of societal institutions (eg. energy problem "caused" by basic limitations on resource availability plus fundamental characteristics of the economy)
Disease syndrome interpreted as basically psychosomatic in origin (eg. reducing effectiveness of the immunity system and allowing it to be overwhelmed by virus; self-destructive behaviour resulting in injury or organ failure, as in alcoholism)	Systemic problem interpreted as basically the result of fundamental cultural trends running into limitations (eg. energy problem as requiring major cultural and institutional shift for its resolution)
Psychiatric disorders	Social and cultural disorders (eg. the unrest of the 1960s)
Natural processes to be facilitated (eg. as in obstetrics and geriatrics)	Natural social processes to be facilitated (eg. metamorphosis-like transformations)

Medical diagnosis is far better developed than the diagnosis of social problems, bu since both types of diagnosis deal with systems, interesting parallels may be observed the authors say.

accomplished by increased reliance
energy-intensive production
ethods in industry, and higher
onomic growth tends to mean higher
tes of resource depletion and pollu-
on. Formulation of the problem as
growth vs no growth" tends to be
nproductive. What seems to be
eeded is a metamorphosis in our
stitutions that will allow us to avoid
oth the problems of growth and of no
owth. Learning to perceive a pro-
em in a different way may be a
ajor step toward its resolution.
istorically, the scientific approach
as been essentially an adversary
rocess of competing perspectives,
ne of which is eventually adjudged
be *the* correct one. What seems to be
quired now is an inclusive process
at recognises that a complete pic-
re is formed only by integrating
ultiple perspectives into what is, in
ffect, a new and larger perspective.

What seems to be required in the
rly stages of problem assessment is a
lerance for multiple interpretations
nd the attendant ambiguity. Yet, we
e accustomed to the opposite in the
olicy process: we seek a single, correct
nalysis through an adversary ap-
roach of competing viewpoints, only
ne of which can be the right one.
he alternative is to explore divergent
terpretations even though some will
e highly controversial or seem absurd.

As individuals we normally live with
nconsistent and conflicting pictures of
eality. Part of growing up is learning
o live with and gain from such inter-
al contradictions. Whether we can
ransfer that process to a conscious
nd intentional system for policy-
aking is uncertain. But an approach
ased on a synthesis of a number of
iewpoints is far more likely to treat a
roblem successfully. Such a synthesis
almost impossible to achieve on the
rink of crisis, when the urgency of
ction demands the acceptance of a
ngle, unifying viewpoint. Hence the
xploratory process required to dis-
lose divergent interpretations should
e initiated through the identification
f future problems well before they
each the crisis stage.

An uncomfortable consequence of
ultiple interpretations of a problem
that the more rigorous analytic
ools may not be very useful. For most
f the perspectives there will not be
dequate data for a meaningful
cientific assessment.

On the other hand, divergent view-
oints are more likely to reveal the
pportunities hidden in problems.
or example, if we had heeded some
f the early signs of the looming energy
roblem, we might have tried to
evelop a more efficient auto engine
hat would not only have helped

Problems 2 and 24

prevent an energy crisis but might also have averted some of our present air-pollution problems.

The positive aspects of the future — the creative opportunities that lie ahead for society — are fascinating to explore, but it is also important to pay heed to the negative side of the future — the domain of social problems. Indeed, there is an intimate complementarity between the two aspects of the future. Approaching the positive side, our imaginations can soar out through time and dream of the world as it could be with the full creative development of the human race; the negative side brings us back to a balanced consideration of the real, the possible, and sometimes the inevitable. Only through a convergence of these two approaches can we have both vision and practicality. To imagine a better world without accounting for the problems of the current world is to engage in fantasy, because every society is inevitably shaped by its response to the problems that confront it.

Of the problems which stand in the way of society on the path to the future, those of the present are always the most troublesome. Clearly, the major problems of today's world will not be solved overnight or even very soon. Yet we know that if man and society are to continue to exist into the future, these problems must eventually be dealt with satisfactorily. Therefore, any realistic images of the future must embody a reconciliation with the realities of the present.

Another kind of problem must also be considered: the problem that is not now obvious, but lies latent in some of today's developing trends. Even before the problems we are all too familiar with are solved, other problems will arise with potentially disruptive or even catastrophic results. If we become so enwrapped in our current crises that we fail to anticipate these less known future problems, we are destined to confront an endless procession of crises from which we may never recover.

We are recognising, however, that many problems that we face today could have been anticipated years in advance, and in many cases actually were. Perhaps the most classic example is the prediction of impending oil and gas shortages that was made so accurately by geologist King Hubbert in the late 1940s and early 1950s, yet was effectively ignored until the energy crisis of the early 1970s. Fortunately, such experiences have begun to convince us that we should pay more heed to predictions of future difficulties even though they may lack the credence of a full-blown crisis. Though we have been relatively successful with a crisis-oriented approach to problem-solving in the past, it is becoming clear that there are enough potential crises awaiting us in the future to overwhelm us if we persist in reactive responses. If we have learned anything from our current problems it is that we must gain the ability to anticipate problems before they become so critical that they evoke panic reactions instead of carefully considered responses. We have been warned, and it may be the last warning we get.

At present, the incentives in our society encourage us to solve problems only when they actually arise; development of the means to anticipate future problems is a significant step toward dealing with such problems. Our study identified a number of problems that might not otherwise have been identified or given credence. Equally valuable was the opportunity to step back from the brink of crisis to see the larger picture and take a longer view. Our project was only a first experiment aimed at developing early warning systems. The procedures need to be improved until they can become an accepted and useful part of the policy-making process. Early warning can only be expected to succeed if it becomes an integral feature of an ongoing process. If it does, our hopes for the future may become more realistic — and more likely to be realised.

Forty-one Future Problems

HERE is the list of long-term societal problems identified by researchers at SRI International's Center for the Study of Social Policy. The emphasis is on national or international-scale problems that could become major societal crises in the coming decades but are not very widely recognised at the present time.

1. **Malnutrition-induced Mental Deficiencies Leading to Social Instability.** Malnutrition during the prenatal period and infancy seems to result in permanent mental and emotional damage. The social and political results of mentally deficient and possibly emotionally unstable populations, especially in the third world where malnutrition is endemic, will be serious for an increasingly complex and interdependent world.

2. **The Cultural Exclusion of the Aged.** In all developed countries, the absolute and proportional growth of the aging population is straining social and economic institutions. Growth occurs through a combination of demographics, lengthening life-span, and earlier retirement. The economic problem is that of an increasing economic load per worker to support the aging, which may intensify the political conflict between young and old. The sociocultural problem is that of wasted lives — citizens without participating roles. The break-down of extended family structures in many nations is making the time of growing old one of enforced idleness and loss of meaning in life. Structural change in society may be required for the eventual resolution of the problem.

3. **Global Firewood Shortage.** About one-third of the world's population relies on wood as its principal fuel. Rising population has created overwhelming demands on forest reserves, particularly in Africa, the Indian subcontinent, and Latin America. The major consequence has been massive deforestation, with resultant flooding, erosion, climate change, and loss of land suitable for farming. The substitution of animal dung for wood fuel has further damaged the soil by denying it natural humus and fertiliser. High prices of fossil fuels discourage wood-dependent peoples from abandoning destructive use of wood and animal waste.

4. **Critical Advances in Biomedical Technology.**

• *Access to Life Extension.* The development of life-extending medical techniques raises important questions about access. Experience with renal dialysis machines indicates that the supply of surgeons and of natural organ or machine replacements will probably not meet demand.

• *Genetic Engineering.* Developments in bioscience, particularly in what is called genetic engineering, pose unprecedented social and ethical problems. The ability to control the sex of human beings and their physical, mental and emotional characteristics (using techniques modelled on animal husbandry) threatens the moral basis of human social organisation.

• *Euthanasia.* Strong movements are developing for the adoption of euthanasia to dispose of the aged and unfit. Supporters of this movement promote the concept of voluntary death for those lacking a place in society.

5. **The Growing Conflict Between Central Control and Individual Freedom.** The advance of science has produced technologies of enormous power, scale and sophistication. The size and scope of both public and private organisations have grown enormously in the past 200 years. Many of society's ills, especially crime, the economy, and energy, seem to be demanding immediate and effective solution.

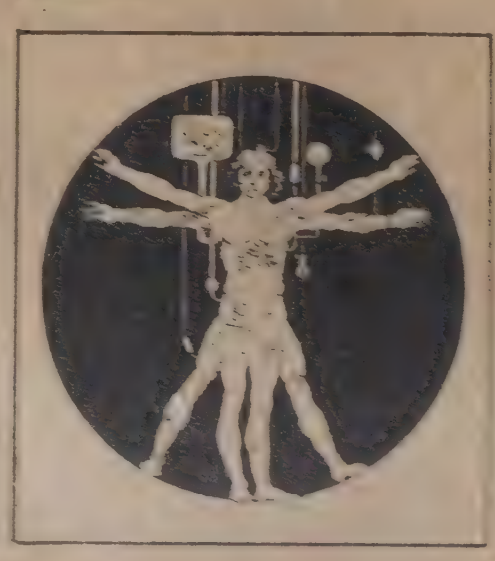
The power of our technology seems to require equally powerful regulation. The scale of our organisations increasingly makes them remote from and dominant over the citizenry. The urgency of problems often seems to demand the sacrifice (albeit willing) of individual freedoms and sometimes of civil liberties (the threat of airplane hijacking led to warrantless search at airports). The decline of social cohesion places ever greater demands on the formal institutions of society. The net result is a reduction in the accountability of institutions, in the efficacy of individual choice, and in the preservation of civil liberties — in short, producing the conditions for a progressively authoritarian society.

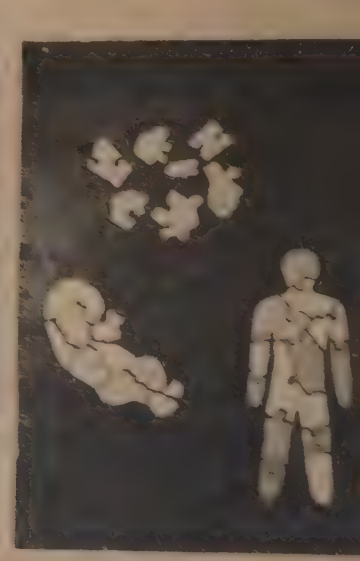
6. **The Conflict Between Growth and Rising Expectati** Worldwide expansion of commu tions and transportation networ leading to rising material expecta and a growing sense of ine among those in the lower econ spectrum. The gap between rich poor nations grew rapidly from $100-$200 (per capita product 1850 to over $2000 in 1970. U recently, world industrial gr was seen as the chief means of clo the gap. However, if the world indeed, facing fundamental limit growth or, for other reasons, nat are unable to achieve growth, expe tions will be frustrated. Widening gap will increase the likelihood political instability and violence.

7. **Police Alienation from Populace.** New technology is ha an unanticipated effect on the na of US law enforcement activi The demand has been for technol cal augmentation and extension each officer's capabilities. The eco mic pressures that necessitate incr ing the area of his coverage, the sp of his response, and the level of f he employs have increased the so distance between the officer and citizens he serves. Alienation of po officers from all segments of society is such that police forces regarded in some places as an ar of occupation.

8. **Loss of Cultural Diversi** The emergence of one interdepend world economy linked by rapid co munications and transportation leading to homogenisation of wo culture. The resulting standardisat would allow greater economic eff ency and greater political and soc stability. However, a culturally unif world might be less adaptable and l creative than a culturally heteroge ous one. It is well known that a co plex ecology (for example, a tropi rainforest) has greater potential f survival and is more stable than simple ecology (for example, mon culture). Moreover, our rich mix cultural systems is worth preservi

Problem 4





cause such systems have intrinsic rth and may also contribute un- standings essential to the solution human problems.

9. **Potential for New Urban olence.** The deterioration of older nerican cities and the decline of eir economies threaten to trap ban populations in a situation not like that of Appalachia. The situa- n of these depressed and despairing glomerations — including already poverished minority groups — por- ds widespread and persistent vio- ce. Quasi-guerilla warfare in the ner cities with raids against out- ng, more affluent areas and assaults ainst police and public service cilities may reach intolerable levels.

10. **The "Invisible" Famine.** en slight variations in world climate n have significant impacts on food d hunger problems. Because this ect is widespread, an "invisible mine" blankets many of the poor tions rather than being focused in a rticular geographic area. The vic- ns are likely to be in less visible ral areas because city populations e fed first to ease the threat of sruption there.

11. **Persistent Malnutrition espite Affluence.** Serious lack of trition as a result of the composition the diet imperils even affluent mericans. New deficiencies are ntinually being discovered as tritional knowledge improves. Well- own problems such as obesity, gar overconsumption, and nutrient moval in cereal processing persist ue to public taste and the influence technology and advertising.

12. **Teenage Alcoholism.** Heavy nsumption of alcohol among adoles- nts (13-18 years of age) is now at bout 25 per cent. This extension of dult drinking patterns into youth oups indicates that the present rious problem of high alcohol con- mption endemic in the United ates may grow worse. Further, enage alcoholism contributes to the roblem of juvenile crime.

13. **Lack of Functional Life kills in Adults.** Recent US Office Education tests indicate that less an half the nation's adults possess e basic skills to function well in day's society. More than 20 per cent e barely able to read want ads or do the arithmetic necessary to use a neque book. These results raise vere questions about the efficacy of merican education and suggest that our society becomes increasingly mplex, many more people will be nable to master the skills necessary function well.

14. **A Growing Subculture of the Information-poor.** A post-industrial society places high value on possessing and effectively using information. However, the gap is widening between those who are information-rich and those who are information-poor. Economic, educational, social and motivational factors create an uneven distribution of ability to make use of our sophisticated new communications technology. More equal access to such technology is an ineffective solution because ability to use the technology depends on the information already held by the user. Thus, those who possess the information can use the new technology to increase their existing advantage over those who have not.

15. **Barriers to Largescale Technological Innovations.** All industrial nations find it increasingly difficult to carry out largescale technological projects in critical fields such as transportation, energy, food production, environmental protection, and housing. Huge public, private, or mixed investment schemes either fail to achieve the promised results technically or prove far more costly than originally estimated (the Concorde SST project). Such failures — contrasted with earlier successes (railroads, airlines, television) — contribute to growing disbelief in promised benefits and discourage both private and public willingness to invest. There is a consequent loss of faith in technology and a growing reluctance to take bold innovative risks.

16. **The Social Impact of Changing Role of Women.** Increasingly, women are entering the work force. Equal opportunity laws and changing mores suggest that many will eventually assume senior positions in government and business. Moreover, they will do so without having to adapt to male behavioural norms. As the number of women in these positions increases dramatically, the nature of the institutions will probably change in response. In the long term, the change should prove productive and beneficial. During the transition, however, internal problems, resembling those of a clash of cultures, can be anticipated.

17. **The Sociocultural Impact of Media.** Rather than direct experiences in the real world, an increasing proportion of people's life experiences are vicarious through the media. Consequently, their perception of social reality may be distorted, and their judgment may be more susceptible to intentional and unintentional manipulation. They may also tend to withdraw from direct political and social participation.

Problem 35

18. **The Social Implications of Changing Family Forms.** During the past decade, the US has seen a drastic increase in the divorce rate and in the number of single-parent families. Traditionally, we have expected the products of broken homes to exhibit undesirable social behaviour. If true, society can expect increased delinquency, alienation, and mental illness. Perhaps as significant is a growing acceptance of the non-permanent marriage and non-related family groups, which undercut older expectations of permanence and family stability. This will have impact on the whole range of social, economic and legal institutions designed for the nuclear family (parents and children).

19. **The Effects of Stress on Individuals and Society.** The negative effects of stress may cost the United States more than $100 billion annually. Although much is being done to treat the symptoms of stress through such remedies as drugs, there are significant aspects of the problem that are barely recognised, let alone studied. There are, for example, different types of stress — some of them potentially beneficial. Our treatment approaches tend to be monolithic, perhaps worsening some kinds of stress. Similarly, we know little about societal stress resulting from individual stresses. Because stress-producing situations such as job and family insecurities seem on the rise, stress-related pathologies will also

Problems 17 and 31

likely increase. At the same time, with growing demand for some form of national health care, the costs of medical treatment of stress-related symptoms could be expected to increase substantially. If the apparent correlation between the rate of social change and social stress is real, it can be expected that stress on the social level will rise as well.

20. **The Potential Use and Misuse of "Consciousness Technologies".** Various "consciousness technologies" constitute an applied science that draws upon medicine, physics, psychology, neurophysiology, and parapsychology. Research is revealing the potential impacts of these technologies upon humankind — both for good and for ill. Whether they present a considerable opportunity or a considerable problem depends on their diffusion and application, as illustrated below:

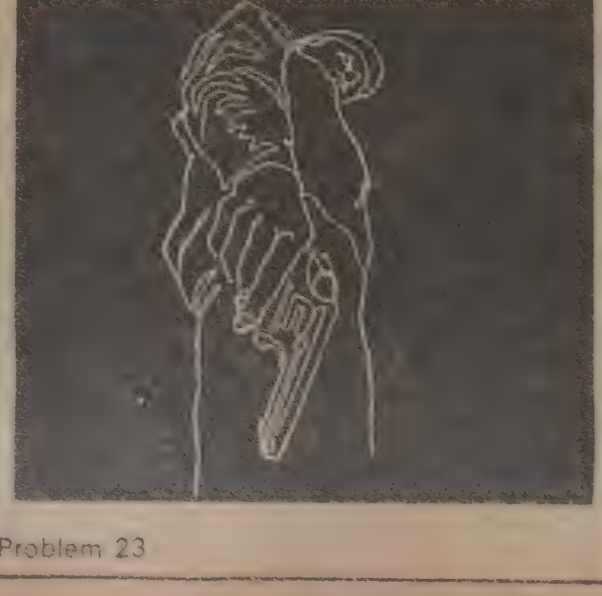
- *Alternative medicine:* A growing body of research indicates that many diseases involve psychosomatic mind-body interaction. If so, integrating the psychological/mind-body component into the treatment would be a potent aid in reducing disease. Serious questions about the fiscal dependability of national health care insurance and the rapid inflation of medical costs indicate that we badly need supplements to expensive traditional medicine.

- *Capacity-enhancing technologies:* Evidence exists that the human potential for rapid learning, creativity, healing and the like exceeds customary assumptions. Consciousness research suggests sociocultural barriers and professional taboos may be restricting application of new techniques in problem solving, health care, education, and criminal rehabilitation.

- *Psychic abilities:* There is growing evidence that psychic abilities may exist and that they may have considerable potential for misuse, principally in two forms: acquisition of confidential information and generation of long-distance effects that could be psychologically disorienting and physically harmful. At present, we have insufficient information to evaluate with confidence whether such abilities exist or the threat presented by this technology of mind — a technology that may be rapidly developed, given current scientific investigations.

21. **Decreasing Capital Productivity of New Technology.** New technology seems to offer increasingly small return on capital investments. Investors fear that prevailing commodity prices in many industries are too low to support the risk and that necessary increases would not be supported in the market. The alternative is to seek government subsidy or tax incentives. However, to do this is to invite government regulation or intervention in business decision-making. Rather than risking an uncertain market or sharing control with the government, industrialists may increasingly elect to restrict their investments and live on past earnings while the general economy stagnates.

22. **Regulatory Restraints and Economic Growth.** Demand for stricter regulation of the economy appears to be rising as a result of more universal appreciation of needs (to contain pollution, conserve resources, reduce hazards), better organisation of special interest groups, higher levels of public support, and distrust of large institutions. Regulation could be restrictive enough to reduce productivity, discourage free enterprise, eliminate development of significant resources, such as oil shale, and increase costs in domains such as coal mining.



Problem 23

23. **Weapons Technology the Right to Bear Arms.** I past, certain weapons (explosive machine guns) have been exclud law from inclusion in the con tional right to bear arms. How new weapons technology, resu from military research and the pu demand for better anticri weapons, is already beginnin strain existing laws. Weapons su electric-shock Tasers and tranqui guns are already widely avail Controlling this proliferation of weapons is difficult because of a ceived growing gap between the allowed the private citizen and arms used by the police and mili

24. **Cumulative Effects of lution.** As new industrial proc are developed and new products manufactured, the number and q tity of new chemical compo released into the environment increased dramatically. The effec these compounds on human h and personality and on the stab of the eco-system may be unknow for years or even generations. large number of such new compo (estimated at about 5,000 per y makes it almost impossible to esta an acceptable testing program which is the necessary first ste determining potential deleter effects. Monitoring of pollut understanding how they reach and his environment, character their interactions with other ch cals, and assessing their potentia inducing low-level, long-term ef are beyond our present capabili

25. **Limits to the Managem of Large, Complex Systems.** power to create large complex syst (economic, political, social) does automatically confer the power effectively control such systems. Th is growing evidence that we h aggregated small, comprehens systems into supersystems that very difficult to manage at all, alone in a democratic, participat fashion. Further, large, complex tems tend toward conditions of r tively low performance as they beco more incomprehensible and less am able to democratic control. There trade-off between reduced efficie and increased capacity for survi through many levels of back-up tems. Large, complex systems a tend to become increasingly vulne ble to disruption at key points a consequence of increasing levels interdependence. They also dema an ever higher level of self-discipl on the part of individuals.

26. **The Apparent Conflict tween World Peace and Wo**

ce. The success of efforts to
e world peace and a tendency
ace peace with stability and
ence of conflict may result in
eservation of existing inequities
and between nations. This
the danger of the defence of
ce in the name of peace and the
r of far more serious and un-
llable eruptions in the future.

Catastrophic Experiments. destructive potential of some nd emerging technologies has questions about whether some mentation might have catas- c results and, hence, should not rmitted. However, the tradi- ethic and practice of science e potential benefit foreseen the successful development of echnologies seem to demand that xperimentation go forward in of the risk. Examples can be from physics (especially the r field) and from the biologi- iences (for example, test-tube ns of new strains of bacteria). echanism exists for identifying ally catastrophic experiments.

Vulnerability of Water ies. The development of highly chemicals and bacteriological ces and the increasing availa- of powerful radiological mate- e a clear and present danger. accidental or deliberate intro- n into public water supply s would have disastrous results. complexity of modern water systems and the vast populations erve exacerbate the problem.

The Dangers of Computer ndency. Increasing reliance on uters and a lag in supporting ons that make computer tech- safe are becoming a national international problem. Legisla- ttention is being given to the f personal privacy relative to uter data banks. However, even serious losses are increasingly ated with the use of computers data telecommunications. In- ions such as electronic funds er (EFT), point transaction au- ion, and process control (such id transit scheduling) entailing fety of human life are accelera- the number and seriousness of due to accidental or intentional ptions or loss of information.

Decreasing Utility of High- ducation. The formal educa- system may be increasingly ient in training people to per- needed tasks, especially those ping with a technologically ced society. The universalisa- f access to colleges and universi- may be diluting the quality of curricula designed for individual personal development.

31. **Effects of Technology on the Individual Psyche.** Constant exposure to technological devices may be having a serious impact on the human psyche. Examples are numerous: media-presented violence with its concomitant effect on the human approach to life; high mobility which leads to rootlessness and weakening of family ties; excessive television viewing, which blurs the distinction between reality and fantasy; an overload of stimuli, which leads to ever higher needs for sensation. Few systematic attempts have been made, however, to observe or measure such changes or to determine their effects.

Problem 29

32. **Loss of Political and Social Cohesion.** There seems to be a decline in political and social cohesion — the sense of shared purpose that provides the balance between individual desires and the general well-being. This decline seems to result from a number of forces, including high mobility; erosion of communities; the replacement of the extended family with the nuclear family; an inward turning to personal goals resulting from a sense of individual powerlessness in a mass society; and the growth in effectiveness of interest group politics. The consequence of this loss is the undermining of the efficacy and legitimacy of society's basic institutions.

33. **Institutional Boundaries as Impediments to Societal Problem-solving.** As the scope, scale, and concentration of human activities have increased, our societal institutions have become more tightly interconnected. Institutional boundaries created for a less tightly coupled society tend to compartmentalise aspects of problems and to resist more comprehensive attempts at solutions. The resulting frustration and conflicts call into question the legitimacy of the entire institutional fabric of the society and generate demands and violent actions aimed at its destruction.

34. **The Need for Better Socio-economic Models.** At a time when the managers of both corporate business and government have developed powerful tools for systems management, it is important that their models be accurate for the systems they propose to manage.

Unfortunately, management technology appears to have grown faster than design capabilities for social science systems. There is a danger that management tools will be ineffective because the social systems model is insufficient for assessing the problem and defining the remedy.

35. **Advanced Microcomputers and Rights to Privacy.** The development of powerful microcomputers, combined with improved semiconductor memories, will make possible inexpensive and highly sophisticated individual surveillance and the maintenance of vast numbers of data banks. Individuals will find it impossible to know who is keeping dossiers on them and what information is in those dossiers. Privacy and other personal

Problems 10 and 40

rights will be threatened as this technology develops.

36. **Chronic Unemployment.** Contrary to many predictions, fundamental changes in the economic situation (for example, environmental and other constraints to economic growth, and basic long-term capital shortage) present the possibility of chronic unemployment. Various analyses indicate high degrees of hidden unemployment at present, and more in the future. Inaccurate identification of the long-term nature of the new unemployment could result in expensive attempts to resolve the problem with the wrong approaches.

37. **Social Response to Energy Disappointments.** Delays and uncertainties will almost certainly occur in obtaining new energy sources over the next decade. In the interim, economic uncertainties will make private investors reluctant to invest heavily in older technologies. Inevitably, strong pressures will be exerted for control of consumption through rationing and for nationalisation of utilities and of the coal, oil and gas industries. These delays and associated conflicts could result in a number of negative social consequences.

38. **A Growing Need for "Appropriate Technology".** There is a growing array of "appropriate" or "intermediate" technology that could provide practical support for a much-simplified way of living. Examples of these technologies include solar power, wind power, intensive gardening, biological means of pest control and fertilisation, and composting toilets. In general, these technologies tend to be ecologically more sound, energy conserving, comprehensible, and efficient when used on a small scale.

As we confront apparent limits to growth — whether induced by economic or political forces — we may have to simplify our level and patterns of consumption. Failure to nurture, in appropriate ways, the development of intermediate technology and suppor-

tive social forms will make i difficult to solve the practic pressing problem of finding ne to live healthily in a world of i ing scarcity. Failure to d appropriate technology woul result in a missed opportuni creative social and technical le during a time of stress and tra

39. **The Societal Change quired to Adapt to New E Sources.** Even though new sou energy from advanced techn may produce abundant cheap e the form in which the energy is able could be quite different fossil fuels. Thus, when dimin fossil fuel supplies have b prohibitively costly, we may ourselves with a system whose ture and behaviour are inappro for the new forms of energy. If n ed changes could be anticipate might more effectively plan term investments and preven desirable consequences.

40. **Emerging Nations an End of Oil.** Over the next 25 as the developed nations inves install new energy sources, the deplete most of the world's oil res As they do so, they will deprive of the third world of access to fuel at a time crucial to develop Because the new alternative e sources may be too complex and for these poorer nations, they m relegated to permanent poverty.

41. **Social Effects of Redef Legal Liability.** Increasing plexity, interdependence, and sc action in society have increase potential liability for decisio individuals and organisations, permitting lines of responsibili blur. Legal devices to avoid resp bility tend to reduce the legitima existing institutions and to rein loss of trust and confidence in in tions and the professions. Lo trust and confidence, in turn, has reflected in increasing resort t courts to seek redress for real or i ined grievances. Consequently, e preneurial and professional risk-t has become far more hazardous.

[All three authors were members of t search team at SRI Inc. Peter Schwart the Project Leader, Willis W. Harma Project Supervisor, and Peter J. Teige member of the Project Staff. The Cent the Study of Social Policy is at SRI Inc Ravenwood Avenue, Menlo Park, Cali 94025, USA.]

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PIDEMIOLOGY

rans-ovarial ransmission of apanese Encephalitis y Mosquitoes

WHEN an infectious agent depends for its maintenance and spread on several extra-human sts, then, its control is possible by terfering with or inhibiting the echanisms or factors involved in its read.

Japanese encephalitis (JE) is caused one of the members of a heteroneous group of viruses called " arboruses " which are transmitted from e infected individual to another by ood-sucking arthropods. The tural history of JE virus is extremely mplicated; it has a variety of hosts e birds and animals including gs, cattle and horses. Several species mosquitoes pick up the virus along th the blood of infected animals and ore important, allow the virus to ultiply inside them. Once infected, ese biting female mosquitoes remain fected throughout their lives. These osquitoes then feed on other healthy imals and humans, and pass on the rus to them. JE virus can cause a vere illness involving the central rvous system. Ecological studies are, erefore, important. Interpretations the data collected from natural ents, or leads for special field search and investigations are made rough laboratory experiments.

Recent experiments by Dr. Leon osen and his colleagues at the ational Institute of Allergy and fectious Diseases, Honolulu, awaii, demonstrate that *Aedes albotus* and *Aedes togoi* female mosquitoes fected with JE virus can pass the rus vertically, to a small percentage their F1 progeny. The adult F1 nale was also able to transmit the rus to newly born chicks (*Science*, **9,** 909, 1978). The occurrence of ans-ovarial transmission of virus by osquitoes was first established by . D. M. Watts and co-workers with e La Crosse virus, an arbovirus, but longing to another group called the alifornia encephalitis, reported ainly from the New World (*Science*, **2,** 1140, 1973). A much higher rcentage of the progeny has been und infected with several members this group in repeated studies. osen and co-workers also mention out several earlier results of isolaons from field-collected material which were considered questionable at the time, but which might be given credence now. One loophole in the present study is the use of intrathoracic inoculation or feeding of the virus-sucrose-erythrocyte mixture to infect the experimental mosquitoes. Although chicks were used as receivers in the transmission experiments, for some reason they were not used as donors to infect the experimental mosquitoes. Had this been done (to simulate natural condition), the results would have been much more convincing.

Studies made in India, following the 1973-74 epidemic of JE in West Bengal, have indicated that in addition to *Culex tritaeniorhynchus* (a mosquito with a predilection to breeding in rice-fields), other *Culex* species and also some *Anopheles* could transmit JE virus (*Indian J. Med. Res.*, **65,** 746). Further, the role of ardeid birds and poultry or ducks might also be ecologically important, particularly in areas where pigs are not in abundance. Thus, trans-ovarial transmission might not be of significance in epidemiology of JE in regions like India, where drastic seasonal fluctuations do not interfere with the year-round maintenance of the virus in nature.

The possibility, however, that other mosquito-borne viruses may be maintained in nature at a low level through such a mechanism is not far-fetched. Occasionally, due to an unusually suitable shift in ecological conditions, such a virus infection may flare up and spread to humans. The suggestion of the authors that such studies be carried out with yellow fever virus is thus important. Investigations of these phenomena, both in nature and in the laboratory, need to be made employing these newer techniques which are more sensitive for detection of arboviruses.

KHORSHED M. PAVRI

[Dr. Pavri is Deputy Director of the Virus Research Centre (Indian Council of Medical Research), Pune.]

GEOMAGNETISM

Trees to Detect Geomagnetic Variations

GEOMAGNETIC pulsations are rapid variations of the Earth's magnetic field in the period range 0·1 to 1000 sec (10 Hz to 0·001 Hz). This is referred to as the ULF (ultra-low frequency) range of natural electromagnetic phenomena. The pulsations have their origin in the distant regions of the Earth's magnetosphere. They can provide information on the regions of the magnetosphere and the ionosphere through which they propagate. Pulsations of lower frequencies are recorded by magnetic sensors with suitably modified instrumentation. More rapid pulsations are measured indirectly by measuring the changes they induce in the Earth currents accompanying them. Any magnetic variation induces currents in the Earth. Known as telluric currents, they were first detected in telegraph poles planted in the ground. Since then, the measurement of these currents has commonly been carried out using two electrodes buried in the ground. To increase the sensitivity of potential measurements, the electrodes have to be several kilometres apart and this makes it rather unwieldy. The alternative method uses coils, tuned to the ULF range, as antennae. The signals from the coil antennae are fed into a system of sensitive DC amplifiers and filters before being recorded. The instrumentation required for this is complex. These problems stand in the way of proliferation of pulsation stations needed to make an intensive worldwide study of geomagnetic pulsations. (We have, at present, four pulsation stations in India — at Choutuppal, Andhra Pradesh, and Ettayapuram, Tamil Nadu, both established by the National Geophysical Research Institute, and the other two are run by the Indian Institute of Geomagnetism at Alibag in Maharashtra and at Trivandrum.)

A detailed 10-year study of the electric potentials of trees undertaken by Burr (*Science*, **124,** 1956) showed that tree potentials vary as most cyclic geomagnetic variations, such as diurnal, 27-day and seasonal. They even show a relation to the 11-year solar cycle. These results led A. C. Fraser-Smith to experiment with the possibility of recording ULF variations in tree potentials. His report (*Nature*, **271,** p. 641, 1978) describes the equipment consisting of 2 steel nails driven horizontally about 0·75 m apart into the cambium (the layer of growing tissue) of the tree. The potential difference between the electrodes was then monitor-

ed with the tree acting as an antenna. Comparing his findings with records from the nearby pulsation station on the Stanford University campus, Fraser-Smith found that Pc1 pulsations (0·2 to 5 Hz) were clearly recorded in the variations of the tree potential. These variations were established to be of geomagnetic origin by testing the system with artificially generated signals. The success of this experiment opens up new vistas in ULF monitoring. Being comparatively simple, the method may be taken up by more observatories. World-wide monitoring of geomagnetic pulsations can provide the key to their generation and their significance in magnetospheric processes.

Investigation of the nature of tree potentials also holds interesting possibilities. The close relation of geomagnetic activity and tree potentials has been established. Perhaps, it has some effect on the growth and vital function of trees. They are yet to be studied.

N. NITYANANDA

[Mrs. Nityananda is a fellow at the Indian Institute of Geomagnetism in Bombay.]

ASTROPHYSICS

Martian Satellite Phobos—a Captured Asteroid?

THE satellites of Mars, Deimos and Phobos, discovered nearly a century ago, have always been objects of speculation. (Curiously enough, Jonathan Swift had described them even before their actual discovery in his famous *Gulliver's Travels*.) Some imaginative people even thought that they were artificial satellites launched by the Martians.

The possibility of Martian satellites being captured asteroids has been considered earlier. But they are in highly circular equatorial orbits and capture of objects in such near-circular equatorial orbit is extremely unlikely.

The Martian satellites are non-spherical: Phobos's dimensions are $20 \times 23 \times 28$ kilometres and those of Deimos are $10 \times 12 \times 16$ kilometres. It is the irregular shape that suggested the possibility of an asteroidal origin. Asteroids, it is known, have irregular shapes and they have highly eccentric orbits.

Observations from the Viking-1 orbiter which had a close encounter with Phobos point to an asteroidal origin for the satellites. Supporting evidence has also come from analysis of earlier data from the Mariner-9 mission to Mars, Viking lander camera and also from Earth-based observations. Viking-1 had its close encounter with Phobos during February 1977 and the result of analysis presented by R. H. Tolson and others (in *Science*, **199,** 61, 6 January 1978) leads to an accurate measurement of the density of the satellite. Two other papers in the same issue of *Science* (p. 64, p. 66 by K. D. Pang and others) describe the measurement of the total albedo and the reflectance spectral analysis. All these results point to the satellite having a composition similar to the so-called 'carbonaceous chondrite-type I. (The carbonaceous chondrites — CC-I — are believed to be the most primitive objects condensed from the primordial solar nebula. The type I carbonaceous chondrites are even more primitive and represent nearly unaltered primordial material.)

TV pictures with an optical resolution of about 30 metres were taken to determine the volume of the satellite accurately. From the deviation of the Viking orbiter trajectory due to the gravitational fields of Phobos, the satellite's mass has been calculated accurately. The density of the satellite is calculated to be about 1·9 gm/cc which is similar to that of carbonaceous chondrites. The density measurement adds support to results derived from spectral ref ance and absolute albedo, which point to the object being CC- origin as discussed below.

The reflected spectrum of Ph was analysed in the region of 200- nanometres wavelengths; it resem the spectral nature of carbonac chondrites in laboratory analyse well as that of some of the aster like Ceres and Pallas. The reflecta remains flat from 1100 to 400 n metres with a value of 5 per cent then falls off rapidly to 1 per cen about 200 nanometres. This behav is quite different from the spec nature of [the Earth's] Moon's flectance or of basaltic rocks. If satellite had shown a basaltic c position, it would mean that it part of a larger body broken pieces; the formation of basalt n melting and mineral differentia and this is not possible in a small b of the size of Phobos. However, present conclusion that it is ca naceous chondrite points to its pr tive origin — condensed directly f the primeval solar nebula. Since believed that material of carbonace chondrite with high volatile cont cannot condense in regions as clos Mars to the Sun, it is likely that satellite was formed in the o regions of the asteroidal belt (wh

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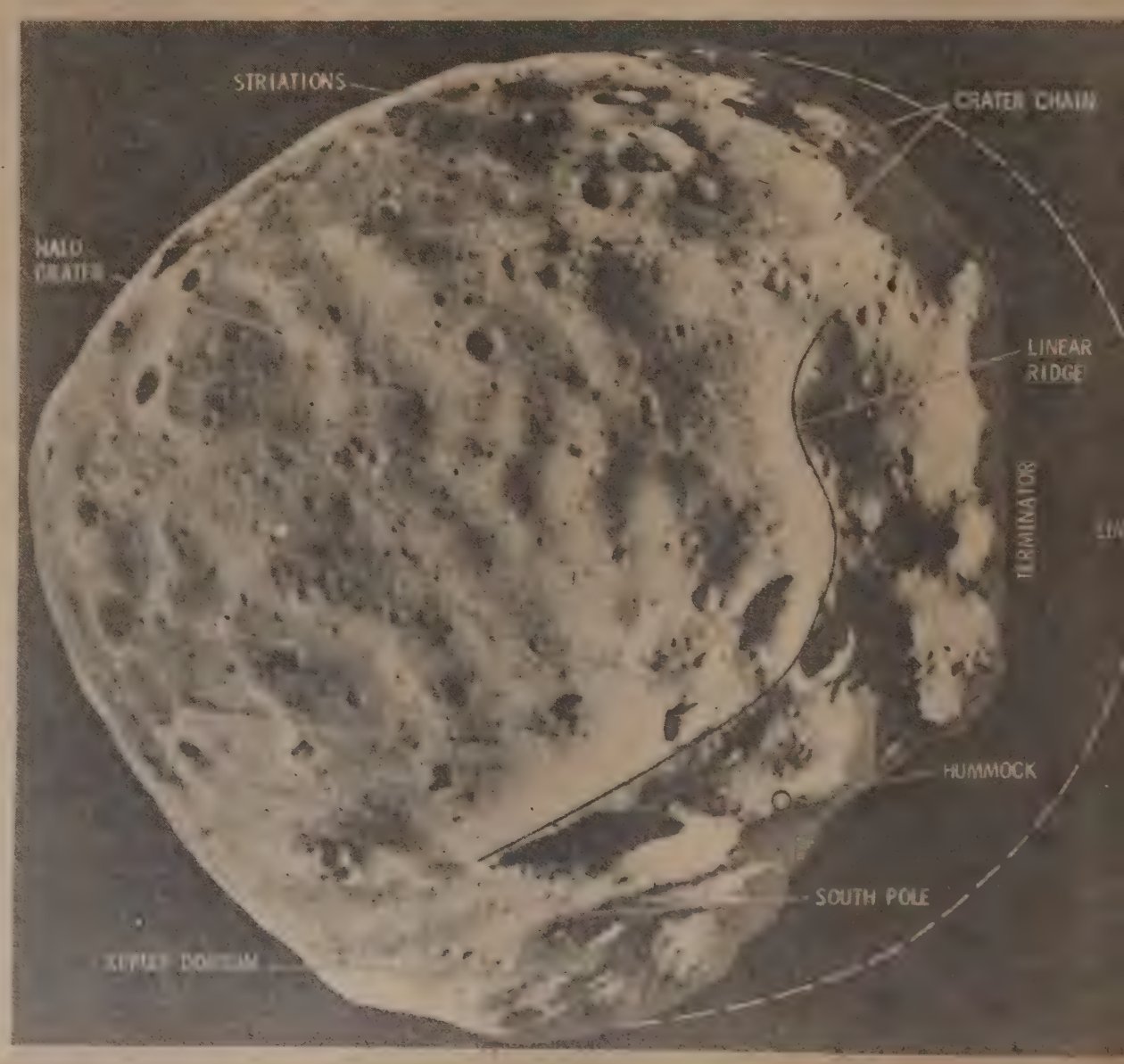
Part of a photomosaic taken as Viking Orbiter was leaving Phobos. The dark region up to limb represents the unphotographed area



LET'S GET TO KNOW OUR TREES!

TREES OF THE DRY REGIONS

A SUBSTANTIAL area of the Indian peninsula receives a rather scanty rainfall. Such elatively drier regions may vary from ne severely arid zones of the Rajas- nan desert to the less harsh semi-arid ands of the Punjab and the Deccan.

Aridity and desertification of lands vhich were once rich in vegetation nay be brought about by natural auses, as in the case of the Rajasthan esert. Only a few millenia ago, this rea was a vast swamp harbouring s own flora and fauna, and into vhich flowed the river Sarasvati (the resent-day Ghaggar) mentioned in ur ancient texts. Historians believe hat some violent upheaval in the Himalayas at the river's source may ave caused the water flow to dwindle nd finally disappear altogether to eave behind a rapidly evaporating wamp — today's Thar desert.

The destructive hand of man is nother cause of aridity. Over the ges, man felled trees and slashed his vay into virgin forest land to make vay for his settlements and acquire nore arable land. Today, the ecolo- gical inevitability of desertification of good lands by wanton tree-felling, overgrazing by livestock and the like nave been established beyond doubt.

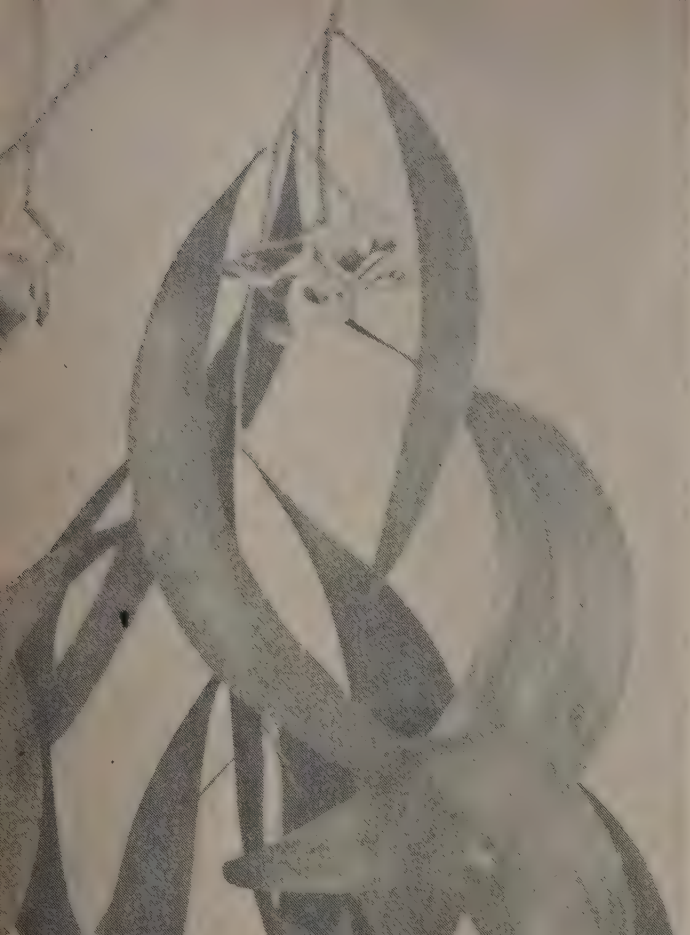
Where the vegetation cover has been severely depleted and the soil so altered as to render regeneration of the original plants difficult, one can see, like in other arid areas, hardy species of trees and shrubs find- ing a foothold and taking over the land, resulting in the establishment of the savannah type of forest. Some adaptations developed by arid zone trees to conserve and utilise ground water are : a deep tap-root system, tough conical spines, tough and leathery or thick fleshy leaves and reduced leaf area. Plants which can survive and grow in harsh arid environments are known as *xerophytes*, derived from *xeros* (dry) and *phyton* (plant).

Anjan tree

The most noticeable tree in this category is the **babool** (*Acacia arabica*). Anyone travelling across the dry Deccan terrain will not fail to see this most conspicuous element of the landscape, with its dark black trunk with chequered bark and spreading crown. If you are a hiker or a cyclist, you must have, at some time or other, been made aware of its existence as its 5-cm-long spines strewn about the ground penetrated a foot or a tyre!

The babool leaf is bipinnate with over 15 to 20 pairs of small leaflets; the two stipules at the base of the leaf rachis are modified into stout and long spines. Though these spines are a deterrent to browsing herbivores generally, goats may be seen to get at the leaves in spite of them. The minute yellow flowers are clustered together in the form of globose heads, and during the rainy season, from June to September, masses of these yellow furry balls are generously sprinkled on the green canopy. Fruiting occurs in the cold season and the pods, each about 12 to 15 cm long, can be seen hanging from the branches in large numbers.

Some varieties of the babool may be encountered in the field. One of these grows straight with its branches arranged like a broom pointing upwards; this type is called *cupressiformis*, and the local folk call it *Ramkati* or Rama's wand. In some places, religious belief about the sacredness of the tree prevents its exploitation. Another variety, called *vedi-babool*, is shorter and more twisted in appearance; this type has flat pods as compared with the beaded pods of the typical babool. Botanists today regard these merely as variants; in fact, the



S. R. Nayak

Australian *Acacia.* Note the tortuously-shaped pods

present botanical name of the babool is *Acacia nilotica* var. *indica*, an Indian variant of the true babool which is indigenous to the African tropics.

Though the babool is partial to a dry climate and arid soil, it can withstand intermittent flooding of the base and indeed thrives best when this happens. Visitors to the famous bird sanctuary at Bharatpur can observe the fine growth of babool in the flood *jheels* during the rains and some time later; during the summer, however, the soil is cracked and bone dry but the babool still survives.

The babool is used by foresters to reclaim bare ravine lands. Babool bark and pod tannins are used for tanning; the fibrous bark can be made into coarse ropes. Another species, *Acacia catechu* or *khair*, is a rich source of *katha* (cutch), a tannin material used for dyeing cottons. When wounded, the babool trunk exudes (after some days) a gum which is edible and is used for preparation of sweetmeats; the gum is also used in printing and dyeing fabrics, paint-making, and in pharmacy as an emulsifying agent. The timber obtained from the heartwood is very strong and durable and is used for making items which have to withstand heavy wear.

The genus *Acacia* provides an interesting example of evolution and adaptation in diverse environments. Almost three-fourths of the world's 600 odd species are found in Australia. Some *Acacias* in Africa have round, hollow expansions at the base of the spines in which vicious ants live and protect the plants from predators (in this case, browsing animals). Such symbiosis is not known in India and Australia. All the Indian *Acacias* have bipinnate leaves, but some Australian *Acacias* have their petioles modified into flat, green, leaf-like expansions (called *phyllodes*), the leaves having completely disappeared! An example of one such tree is *Acacia auriculiformis*, introduced from Australia as an ornamental roadside tree and for purposes of reforestation of dry tracts. Another tree introduced for ornament is the scented babool or *cassie* flower, *Acacia farnesiana*, a small tree grown as a hedge and also for its perfumed globose flower clusters. A perfume called *cassie* is extracted from the flowers.

Another tree of the dry regions, known and worshipped since ancient times, is the **khejra** (Hindi) or **shami vriksha** (Sanskrit) (*Prosopis cineraria*). This is a common tree found mainly in north India but is also grown in other places, especially near temples. The shami is a rather small-sized tree, not exceeding 16 metres in height, armed with spines, with a rough, grey bark which peels off from time to time. It is found scattered amid the savannah vegetation and sometimes grows gregariously in good alluvial soil, especially near river banks.

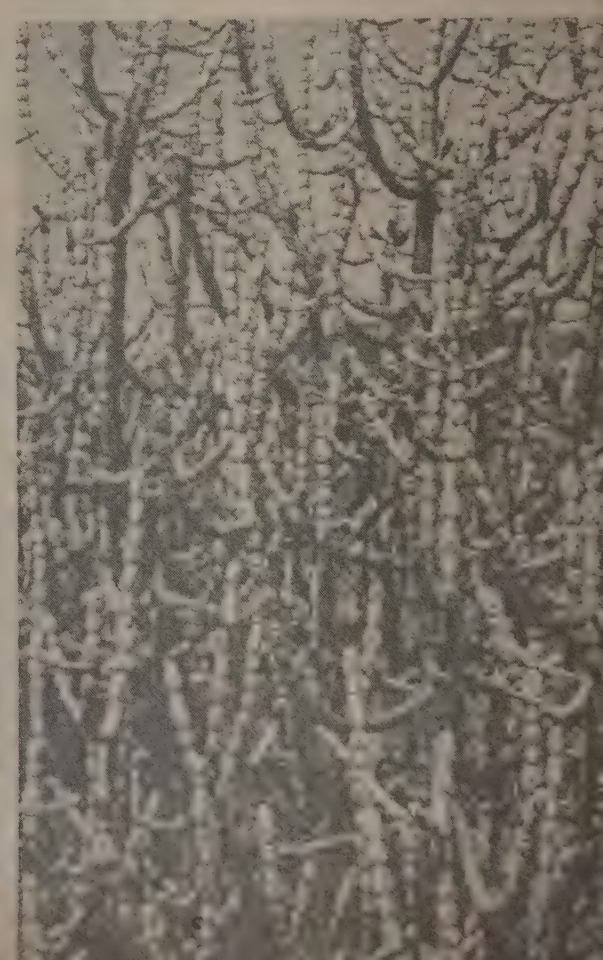
Like other members of the same family, the shami has bipinnate leaves. Each leaf possesses two pairs of pinnae with about 10 to 12 leaflets each. Small round insect galls may be found sometimes on the main leaf stalk. The small yellowish-white fragrant flowers appear from March to May in spikes in the leaf axils. The pods ripen from June onwards; each pod has about a dozen seeds surrou ed by sweet pulp. The pods readily eaten by birds and anir which are chiefly responsible dispersal of the seeds. Generally, dry areas, the tree produces suckers from which regeneration propagation take place, but on g moist soil, new plants can grow fr the seeds. Seeds carried by river wa are deposited high and dry on banks when the water recedes; h the shami is usually the first to gr and colonise, its long taproot syst enabling it to outlive many ot plants.

The shami yields a rather sm amount of timber which is only v occasionally used; because it is c sidered sacred, the tree is rarely fell The sweet pods are edible and ar great favourite of village folk Punjab and Haryana; they can consumed green, or when boiled dried; they are claimed to astringent and demulcent. An analy of the pod pulp has shown that it a high protein content, over 11 cent, and would contribute a go deal to the nutrition of the lo people if properly exploited.

The *shami-vriksha* has figured in o ancient epics and is of totemis significance in the lores and beli of some adivasis of Western Ind Rama, the hero of Ramayana, is sa to have bowed to the shami t before embarking on his mission fight and kill Ravana, the King Lanka. In Mahabharata, the fi Pandavas are believed to have co cealed their weapons on a shami t during the last year of their ex when they lived incognito in the ci of Virat. On the tenth day of t bright half of Ashvin-Shuddha (that September-October) they worshipp

(Right) *Euphorbia* plant. (Below) Close-up of *Euphorbia* flower

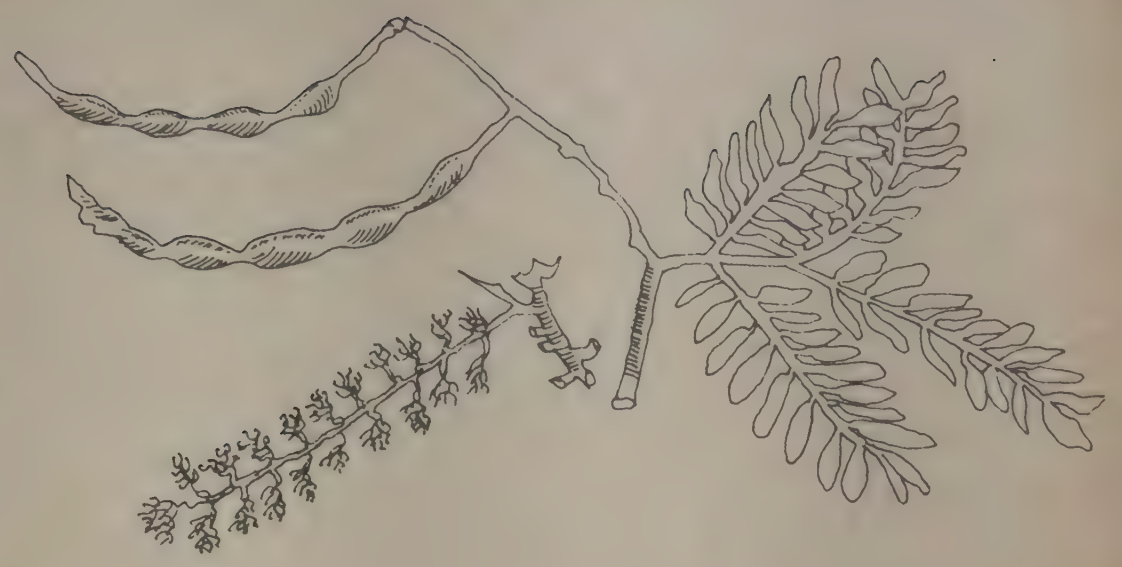
S. R. Nayak



S. R. Nayak

(Left) Pod and leaf of anjan

(Right) Pods, flowers and leaves of shami



this tree for having been the custodian of their weapons. This is, perhaps, the origin of the practice of worshipping the shami tree on Dassera day. The Maratha warriors of yore, too, started their campaigns on this day when leaves of the shami were distributed after worshipping the tree; the practice of giving these leaves or those of the *apta* (*Bauhinia* sp.) is still in vogue.

Dry shami twigs are used as *samidhas* for feeding the sacred fire and leaves are offered (*patris*) during the Ganapati puja. Also among some adivasis, the shami is regarded as an ancestral spirit (*devak*). Others believe that circumambulation of the tree by women overcomes sterility; yet others, especially in Gujarat, hold that the shami is the abode of evil spirits.

A similar small tree, the American mesquite (*Prosopis juliflora*), was introduced into India in 1876 by Lt. Col. R. H. Beddome to colonise and clothe arid terrain. Now naturalised, quite often this tree is grown near villages as wind-break and for fuel. Its timber obtained from aged moderate-sized trees is said to be strong and durable and is used for agricultural implements. A gum from this tree is used for sizing cloth and paper. Its tender leaves ground with *gur* gives quick relief on application to scorpion stings.

The drier regions of the peninsula, where a savannah scrubland predominates, sometimes harbours very valuable big trees. The **anjan** (*Hardwickia binata*) is one such tree which grows in isolated communities widely separated from one another. It grows in Khandesh and nearby Madhya Pradesh extending to the Satpura range; elsewhere it grows in some districts of Andhra Pradesh and Tamil Nadu. The wide geographic separation of these two distributional areas of the anjan has been something of a riddle to botanists.

The anjan is an extremely hardy tree which, if not interfered with, can grow to over 30 metres in height. In the hot desolate stretches where it grows, the anjan indeed presents a beautiful sight, especially in the summer — with its grey bark deeply grooved by vertical furrows and peeling off in places, and the profusely branching crown and drooping handsome branches. Most trees, however, are lopped frequently and, therefore, do not grow to good proportions; one then sees only twisted and deformed trees.

The small 5-cm-long leaves of the anjan at first sight look remarkably like those of the *Bauhinia*, but a closer look reveals the difference — an anjan leaf has two parts (bifoliate) which are not united at the margins like that of the *Bauhinia*. The leaflets are a greyish-green in colour and leathery and fibrous to feel. New leaves which appear in April and continue into the rainy season are tinged with red — a very charming feature for a tree with such a rough exterior. During the peak of the monsoon, from July to September, small yellow flowers bloom on loose short stalks. The fruits (pods) ripen in April and May. Each flat pod is about as long and as broad as one's little finger, a light yellow-brown in colour and ridged with parallel veins. The single flat seed is located at the tip which splits open at the time of germination. The pods, being light and flat, are carried by the wind over fairly long distances. Though the pods germinate during the rains, the usual method of natural regeneration is through production of root suckers. The anjan bears pods only once every three to five years.

Anjan wood, a rich red-brown colour, is one of the finest timbers known — hard, durable, resistant to fungal and termite attack. It is used for making strong implements and for ornamental work. The bark can be made into coarse ropes for local rural use. The leaves are an excellent fodder for livestock, containing as they do over 10 per cent of protein; this is one reason why the tree is so frequently lopped.

When hill slopes or rocky areas are laid bare following destruction of natural vegetation, one of the first species of plants to invade the patch and thrive is the **thohar** (Hindi) or *snuhi* (Sanskrit) (*Euphorbia neriifolia*). Like many other arid zone plants, the *Euphorbia* has spines and scanty leaves; in addition, it has a thick milky latex in its tissues to aid conservation of water.

Numerous species of *Euphorbia* are found in India, but the thohar is by

Salvadora

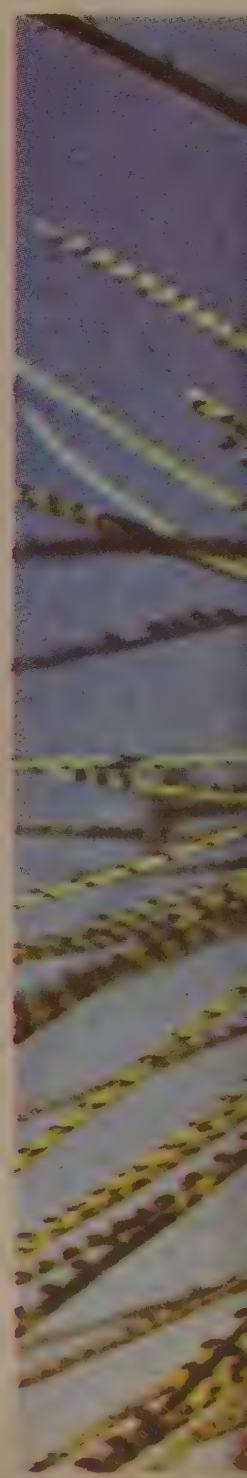
S. R. Nayak

far the commonest. The thohar is generally like a shrub but often grows to six metres or more in height and assumes the proportions of a small tree. It has a thick fleshy stem and a many-branched fleshy crown which has an uncanny resemblance to a cactus, so much so that it is often called a cactus by the layman. The *Euphorbia* in reality is a dicotyledonous tree belonging to the family Euphorbiaceae, whereas the true cactus family (Cactaceae) has no representative in India.

The thohar is generally leafless most of the year but bears 30-cm-long leaves during the monsoon. Each leaf is smooth, thick and has a rounded apex, and possesses two short sharp spines (modified stipules) at its base. The point of attachment of the leaf is in the form of a raised tubercle and when the plant is leafless the vertically spiral placement of the tubercles can be seen. In the summer the small three-flowered cymes appear in March or April; the central flower is male, and the two lateral flowers are bisexual which develop later into groups of three capsules. Armed with a good magnifier, a botanical guide to floral structure, and an insatiable curiosity, one may examine the architecture of these remarkable petal-less flowers. Swarms of rock-bees are attracted to the flowers which offer small amounts of nectar.

The thohar is planted as a hedge plant to keep out cattle. Its latex is irritant and can cause vomiting, purging, and skin irritation. It is toxic to livestock and is not eaten by them. Its juice was an indigenous remedy for earache and asthma. Animal experiments have shown that the plant causes damage to the kidneys and the liver.

(Below) Flowering branch of scented babool S. R. Nayak



Throughout the drier regions of our land, a small xerophytic tree of tropical America, *Parkinsonia aculeata*, has established itself and become naturalised. Known as the **vilayati-babool,** it is planted near villages and towns for beautification and also for reforestation.

The vilayati-babool is an unusual member of the family Caesalpiniaceae (to which the exotic gul-mohur also belongs), for its leaves can often be mistaken by the uninitiated for small green branches. A close scrutiny shows that the minute flat and oblong disc-like "leaves" are really the pinnules of a larger bipinnate leaf, the main rachis of which is long and ends in a sharp spine. The tree does not usually attain a height of more than four or five metres and generally presents a rather drab appearance

S. R. Nayak

(Left) *Acacia arabica* with two doves perched on the tree

(Below) *Parkinsonia*

S. R. Nayak

most of the year. In the summer, however, it displays its bright yellow flowers in short clusters. At this time it is indeed very attractive and eye-catching, all the more so because it adds an unexpected splash of colour to the hostile arid environment. The tree bears slender pods containing longish ovoid seeds which are edible.

The vilayati babool regenerates from seeds or shoot cuttings. Its branches are used as livestock fodder. All parts of the plant are reputed to have medicinal properties, for example, the leaves are antipyretic, diaphoretic and even abortifacient. Rural folk use the rather scanty wood as fuel and some attempts have been made to use it for making paper pulp.

A characteristic of most arid zone trees is their sparseness in terms of numbers of trees. While pure stands of *Acacia*, *Hardwickia* or *Prosopis* are sometimes seen, the individual trees are usually spaced at greater distances from one another as compared with the compact huddling of trees of other forest types. Among these trees one may come across some less familiar species — one such is the **kharjal** (Hindi) (*Salvadora persica*), believed to be the mustard tree of the scriptures.

The kharjal has a sparse distribution throughout the dry regions in India, and also on the sea coast where it may be associated with the littoral vegetation. (It would be valid to regard the sea coast as an arid zone, too; despite, its special feature of salinity, here, too, the soil is often sandy and deprived of fresh ground water.)

The kharjal, which is often planted in villages as wind-breaks, and for its medicinal value, has the appearance of a shrub generally, but when fully grown is a moderate-sized tree with soft greyish-white bark which is deeply fissured and cracked. Unlike most xerophytes, it does not have thorny spines. The leaf is thick, fleshy and turgid; it breaks but does not bend. The leaves have a salty and tangy taste and are sometimes eaten or made into a sauce. Camels and goats eat the leaves with relish. Many small greenish flowers bloom on the slender branches late in the year, and small, round, fleshy, red fruits (drupes) resembling berries, each the size of a very small pea, appear. The ripe fruits are sweet and edible, but the raw green drupes are sharply acrid and unpleasant (they smell and taste somewhat like the stem juice of the *papaya*).

In rural medicine the kharjal has many uses: the root bark is a vesicant and is often added to snuff; it is used as a paste for application to painful areas as a substitute for mustard plaster; the liquid obtained by boiling and straining the root bark is used to promote menstruation. The stem bark is thought to expel intestinal worms. The edible leaves, though astringent, are administered in cough and asthma and made into a poultice for rheumatism; the fruits are used to increase urine flow, and claimed to dissolve urinary stones. The seeds have a purgative action and the seed oil is used as a rub for rheumatic pains.

The flora and fauna of the arid regions have an appeal of their own but one can intuitively separate those areas produced over the millenia by nature, and those rapidly caused by man's activities. The former are havens for interesting species which have developed through adaptation to the apparently hostile environment, whereas the latter are the bane of the forester and environmentalist alike who are both interested in reclaiming lands already so insulted and arresting the process of desertification.

Need we say more?

S. R. AMLADI

The Sinograph

HERE is a simple device you can use to draw sine curves to represent a variety of waves — sound waves, alternating electricity waves, mechanical waves, clipped waves, modulated waves — that students of physics, mathematics and engineering come across. Called the Sinograph, it is the invention of a young student, Master Jose George Maliakal of the Birla Public School, Pilani, (Rajasthan) and his mother, Dr. (Mrs) Rosie George Maliakal.

The sine is a function of an angle which is the ratio of the side opposite it or its supplement to the hypotenuse. When particles execute vibrations of a simple harmonic type they are said to generate a sine wave. To put this wave on paper in the form of a curve is not child's play, because you must tabulate the sines for various angles with the help of a logarithmic table, plot the points on a graph sheet, and draw a smooth wavy line passing through these points before you can get a sine curve.

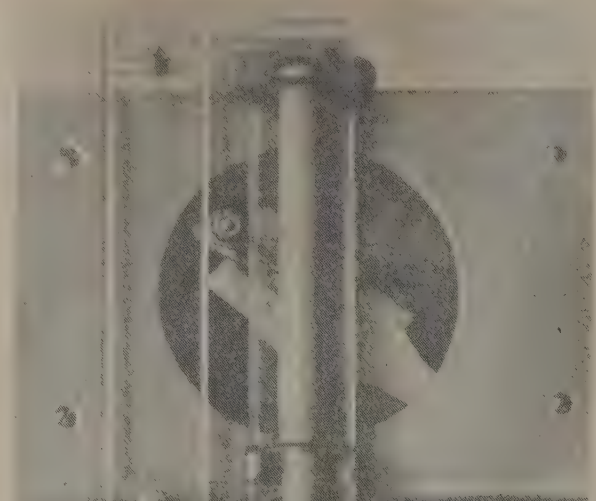


Fig. 2 Front view of the sinograph

Master Maliakal's invention is based on the principle of the toddler's wheel. There are four wheels that support the frame of the sinograph (Fig. 1), the two rear ones being firmly linked by a transverse axle. A pair of bevel gears connect the transverse axle to a longitudinal axle. The sinograph wheel is fixed at the free end of this longitudinal axle in the transverse plane. A peg on the sinograph wheel is engaged in a slotted bar carrying a stylus and moving freely between the grooved rails.

When the sinograph is moved on a sheet of paper by applying a slight downward pressure and a linear force, the rubber wheels rotate the transverse shaft. The bevel gears transmit the motion to the longitudinal axle and the sinograph wheel. The rotational motion of the sinograph wheel is converted by the slotted bar and the grooved rails into linear reciprocatory motion. The writing style attached to the slotted bar is therefore subjected to two simultaneous movements, ie, the longitudinal motion of the chassis and the linear reciprocating motion. These two movements are linked in time and space, so that in the normal mode of operation, the reciprocating motion is simple harmonic with respect to the longitudinal motion of the sinograph. Thus, the writing style traces out sine curves, the resultant motion of the two movements.

To accomplish amplitude variation, the position of the peg is shifted in the slot of the sinograph wheel. Frequency variation is accomplished either by replacing the wheels by bigger or smaller wheels or by changing the bevel gears. Other wave-forms such as clipped waves, half-waves and fractional waves can also be obtained by restricting the sliding motion of the slotted bar by means of a spring limiting bolt. Modulated waves, where the amplitude of oscillation changes, can be obtained by providing the sinograph wheel with an eccentric wheel which can, if required, rotate independently of the sinograph wheel (Fig. 3).

The Sinograph is patented in India under Patent No. 140442, dated 22-1-1976 and the estimated manufacturing cost is around Rs. 100 per unit. It has won the inventors an award of Rs. 500 from the National Research and Development Corporation, New Delhi.

BADIUDDIN KHA

Fig. 1 Top: Plan of the sinograph. Bottom: Front elevation of sinograph

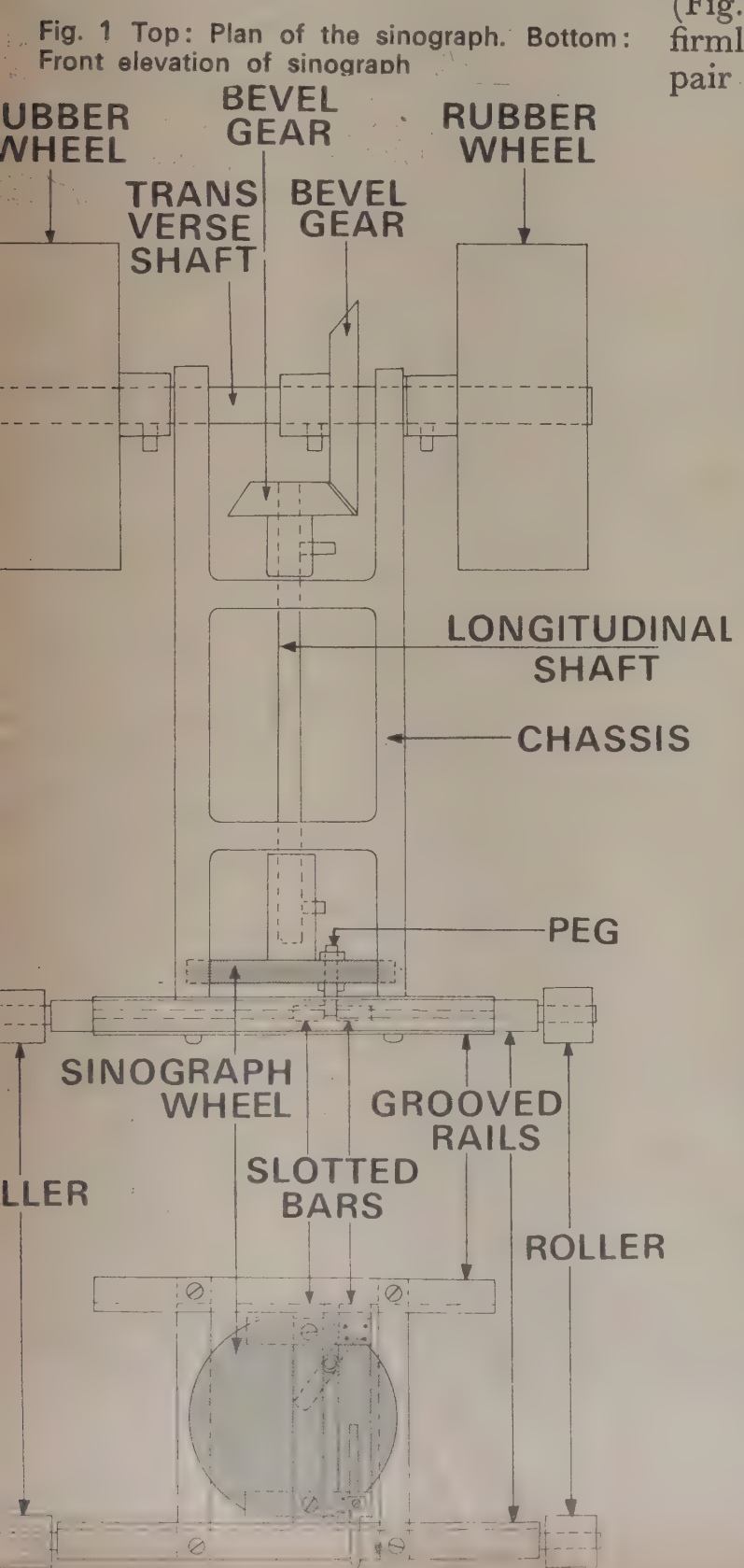
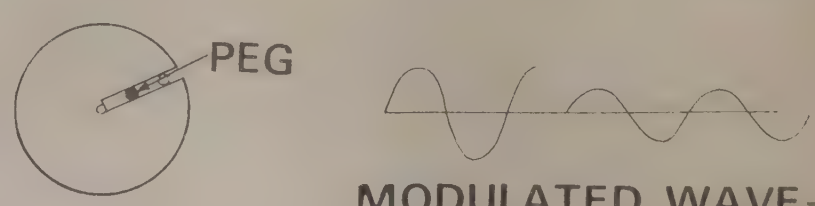


Fig. 3 How a modulated wave is produced by the sinograph



Rust-proof Packaging Paper

METAL components can be kept from rusting in transit and storage, for six months to ten years, by wrapping them with paper coated with a substance that volatilises and saturates the enclosed space. Such anti-corrosion packaging paper, which obviates the botheration of having to apply preservatives to the surface to be protected and removing them before use, has been developed by K. S. Rajagopalan, N. Subramanian and M. Sundaram at the Central Electro-chemical Research Institute (CECRI), Karaikudi. It received an award from the Inventions Promotion Board.

Ferrous components may be fabricated in one shop and assembled in another, or kept in stores and issued when required. It is necessary to protect

em from corrosion and rusting uring transit and storage. One f the important developments in orrosion-prevention during the last ree decades is anti-corrosion pack-ging paper.

Anti-corrosion packaging paper is ackaging material (unwaxed neutral raft, waxed neutral kraft, bituminised raft laminate) coated with a volatile ubstance or mixture of volatile sub-ances known as Vapour Phase orrosion Inhibitors (VPIs). These ubstances volatilise and saturate an nclosed space. When moisture in the nclosed space condenses on the metal urfaces due to diurnal variation in emperature, the volatile corrosion nhibitor also condenses with the noisture and inhibits corrosion by the noisture. Even when corrosive apours like sulphur dioxide or fine alt particles from industrial or oastal localities are present in the tmosphere, the inhibitor by con-ensing with the moisture can inhibit orrosion.

All that is required to protect an rticle is to wrap it with the anti-orrosion packaging paper and place inside a carton. Even this is not ecessary if the cardboard or wooden arton is lined inside with the anti-orrosion paper. Where the item simply wrapped, the protection ay last only for six months; where ne package is dipped in wax and ade water-vapour proof, the protec-on may last for 10 years and more.

A large number of stable organic ompounds were screened at the ECRI for the vapour phase inhibit-g property. Derivatives of naphtha-ne and benzene, by-products of the oke-oven industry, which can be asily produced in this country, were und to give vapour phase inhibition. aboratory tests at different humidi-es, under continuous condensation onditions, and at elevated tem-eratures were carried out with these hemicals in powder form and as oating on kraft paper, followed by eld trials with wood screws, nails, nd various other items in storage.

A laboratory-scale coating unit as ell as a commercial-scale coating nit were designed in the Institute nd got fabricated in the Institute orkshop.

The know-how developed at the ECRI has been released to three arties. The cost of this paper is pproximately Rs. 2/sq m, which ompares very favourably with that f the imported paper and other ethods of temporary preservation uring storage and transit.

P. K.

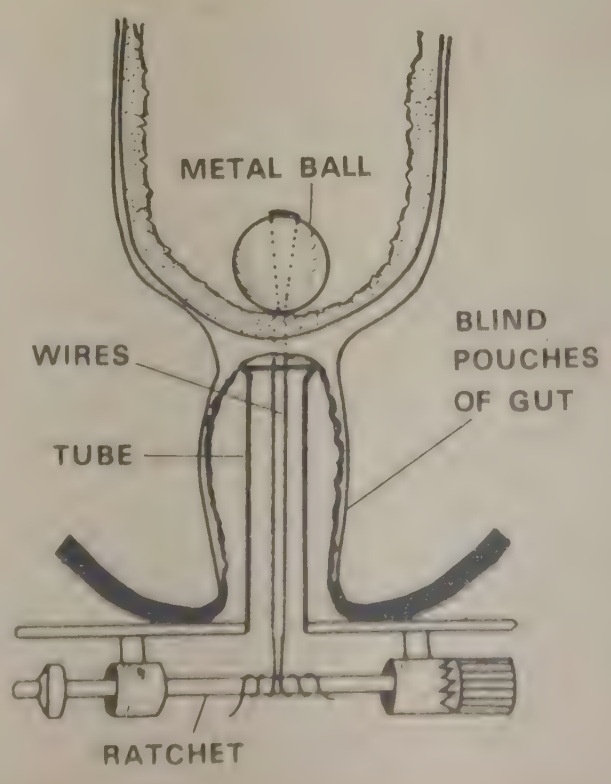
New Instrument for Ano-rectal Surgery

A NEW instrument for correcting defects of the rectum and colon in newborn infants, developed by Dr. P. Upadhyaya, Professor of Paediatric Surgery, All India Institute of Medical Sciences, New Delhi, bids fair to replace the current tedious surgical techniques adopted in such cases.

A large number of infants are born with structural or functional defects of the region of the rectum. These may be anatomical abnormalities such as rectal atresia or functional defects like congenital aganglionic mega-colon, commonly known as Hir-schsprung's disease. Rectal atresia is a rare type of anomaly involving the middle part of the rectum — in fact, the middle part of the rectum is missing and the lower and upper ends of the rectum end as a blind pouches. These blind pouches have only fibrous tissue between them. Hirschsprung's disease, on the other hand, is a functional anomaly. The anal canal, rectum and colon appear normal; however, the nerve ganglia normally found between the intestinal walls are missing. As a result, the peristaltic motion of the intestine is absent and the intestine gets blocked.

The patented device consists basically of two parts (*a*) a metal ball and (*b*) a cylindrical metal tube with an everted rim at the upper end providing the seat for the ball. The tube is mounted on a metal plate with a ratchet arrangement to bring the ball into forceful approximation with the seat by means of stainless steel wire.

Sectional view of the device: the metal ball is brought into forceful contact with the tube by tightening the wire on the ratchet



A temporary colostomy (an external opening in the large intestine) is performed at birth to relieve intestinal obstruction. Around the age of six months, the device is placed in position. After a thorough bowel preparation, the abdomen is opened in the midline or through a transverse lower abdominal incision. The metal ball, threaded on steel wire, is introduced into the upper rectal pouch in the case of rectal atresia or into the normal segment of the colon (i e, having ganglia) after the segment without ganglia is removed in the case of Hirschsprung's disease. The stainless steel wire perforates both pouches and lies in the anal canal. The metal tube is inserted into the anal canal or (the lower rectal pouch) around the steel wire, which is threaded into the ratchet axis. As the ratchet wheel is tightened, the ball is brought into forceful contact with the seat of the tube, thereby crushing the intervening segment. In less than a week, the crushed segment dies, the mucosa of the two segments grow towards each other and the device slips out spontaneously. After three or four weeks, gradual dilatation of the rectum is started and when a good size opening has been created, the colostomy is closed.

This technique has considerably simplified surgery for rectal atresia and Hirschsprung's disease: it restores the continuity of the inside of the gut without interfering with its functioning; it is a simple procedure involving minimal dissection and tissue trauma and therefore, reduced operating time and reduced blood loss.

The new technique is claimed to have established its utility in a number of cases of rectal atresia and Hirschsprung's disease, and is expected one day to become widely accepted as the procedure of choice. The instrument has won for Prof. Upadhyaya a prize of Rs. 2,000 from the National Research and Development Corporation.

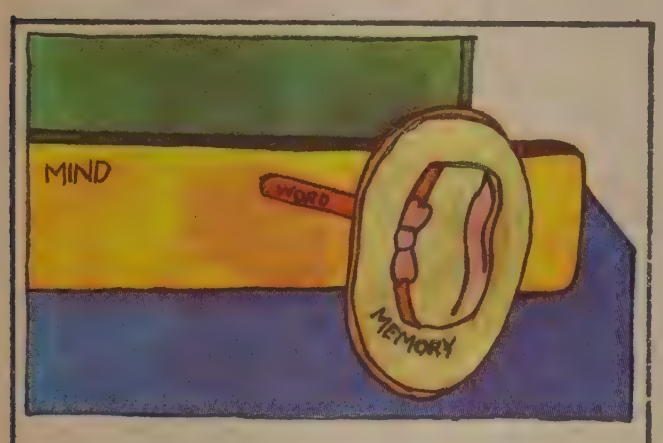
P. K.

(Contd. on p. 34)

STEP TWO

Here we deal with the " peg system ". An advantage of the peg system is that it will not only help you to remember lists of words in a sequence, but will also help you to remember the items in and out of their correct numerical order.

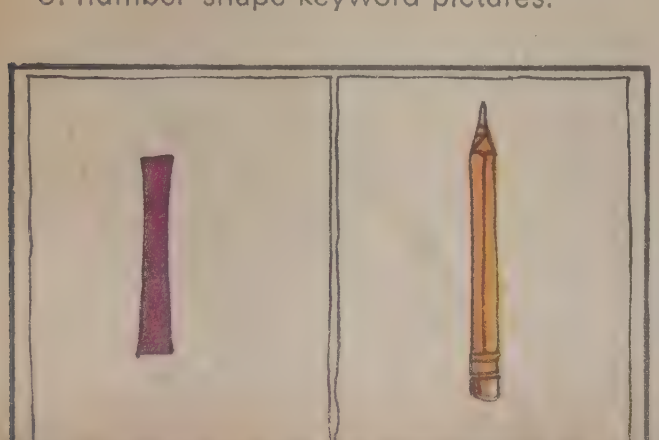
Take the list of 20 words we had dealt with last month — beginning with bottle, table, legs, and so on. Now, can you recall which was the 17th word in the list? Or, the eighth? The ' chain system ' introduced as STEP ONE (last month) would help you recite the list in order but you would still have to strain to rattle off the words in, say, reverse order, or in a random manner. The "peg system" doesn't have that drawback.

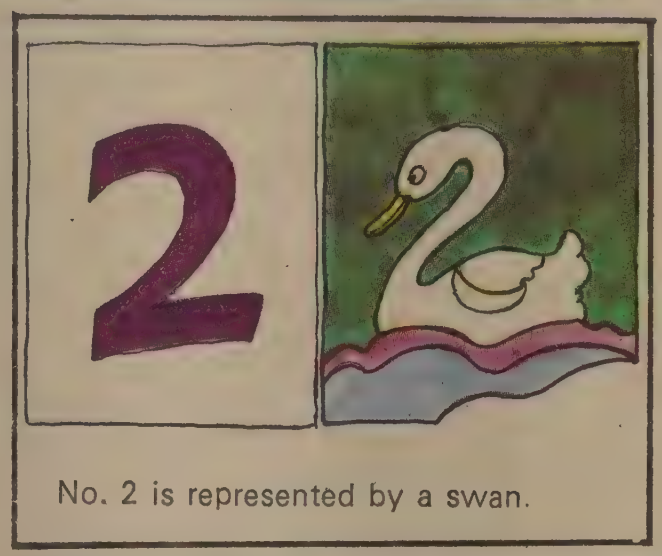


Before we begin to memorise any list, we must know a list of *permanent words*. Let's call them PERMANENT MEMORY PEGS. Anything you wish to remember can be firmly hung on these memory pegs. What's more, you may have any number of pegs, or as many sets as you wish.

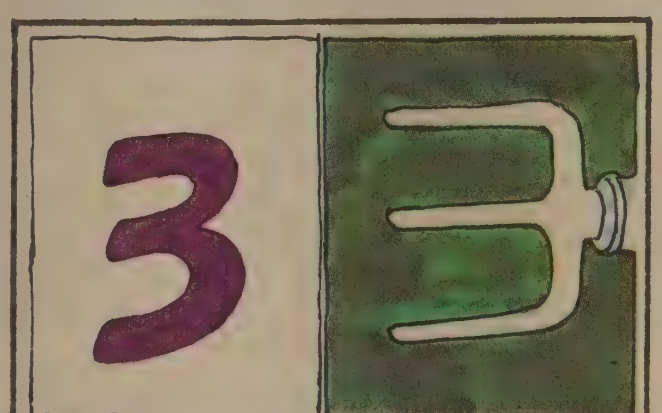
NUMBER-SHAPE PEG SYSTEM

To help you invent your own associations, here's some help to draw up a list of number-shape keyword pictures.

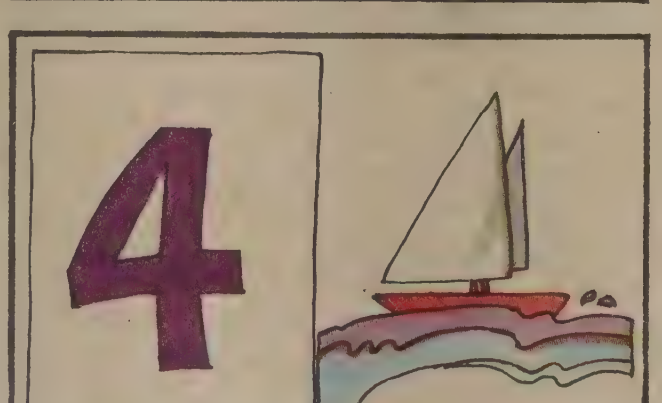




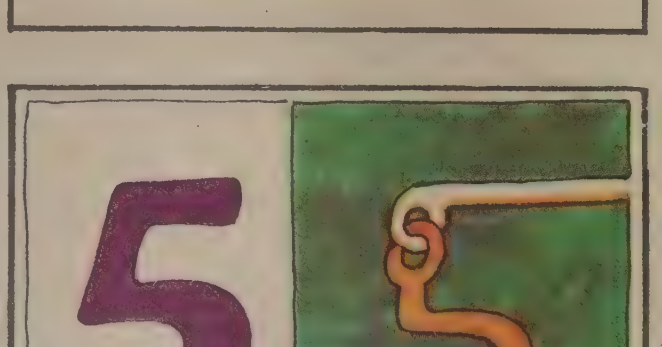
No. 2 is represented by a swan.

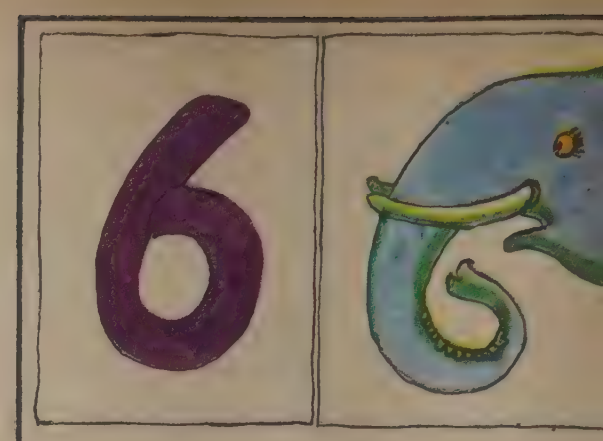


No. 3 by a pitchfork.

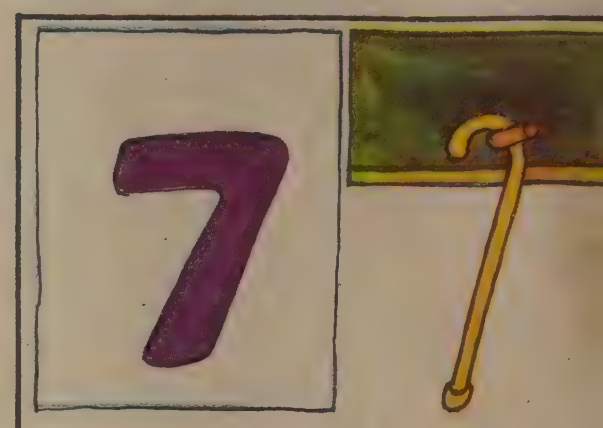


No. 4 by a sailboat.



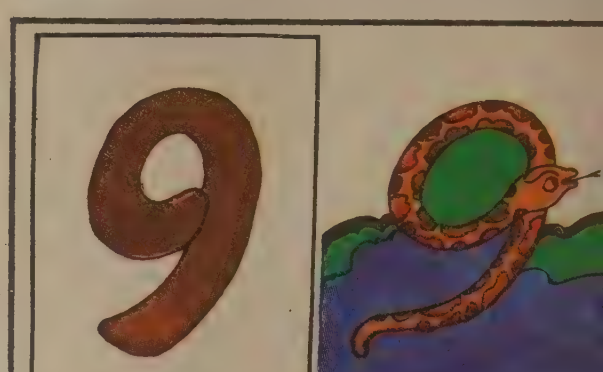


No. 6 is like an elephant's trunk.

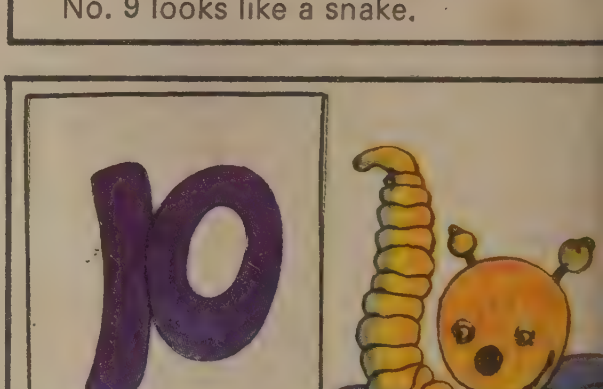


No. 7 is a walking stick.

No. 8 is a snowman.



No. 9 looks like a snake.



. . . and No. 10 is a snail.

These pictures — the pencil, the sw
the pitchfork, etc — will be your co
stant memory pegs. So make sure t
they remain in your mind as go
visual images.

What we are trying to do is take t

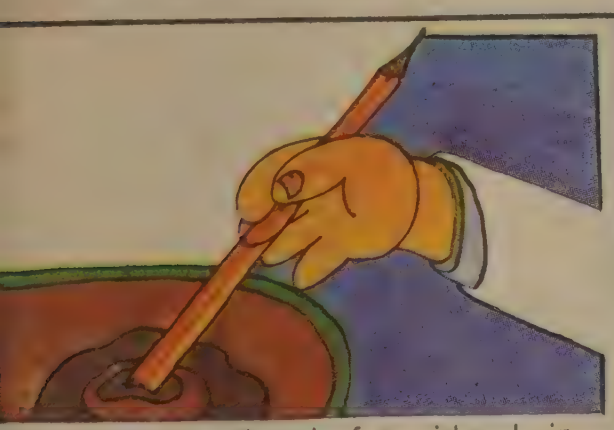
asically unconnected items — a number nd an object — and associate them rough the idea of a shape.

Now, close your eyes and run rough the numbers and their associat- d shapes. As we move on to the EG SYSTEM now, you will have to eep in mind, visually, each of the ten egs of the number-shape order.

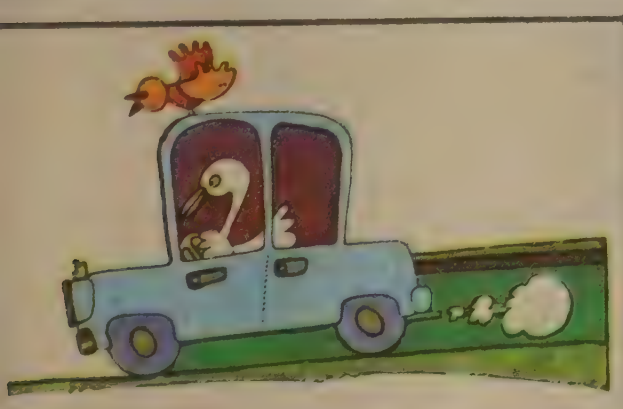
BOWL TAXI TOOTH CARPET NCLE BALL PIG FLOWERPOT ILVER GUITAR

Try to memorise the words, in and ut of order. What you have to do is ick out each word from the list and ssociate or relate it with the appro- riate number-shape word.

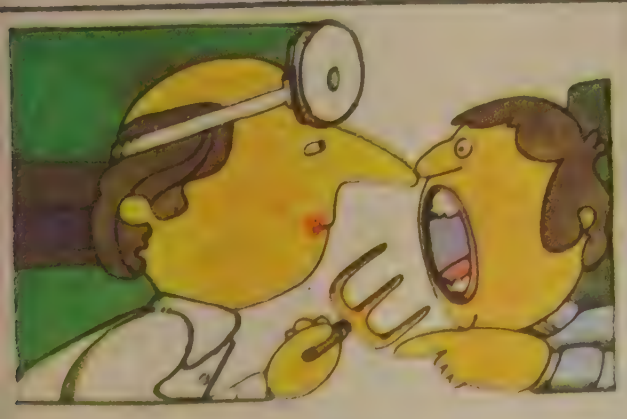
Take the first word from this list and ssociate it with No. 1, so that you can roduce a good visual. . .



. . . such as a bowl of porridge being stirred with a pencil.



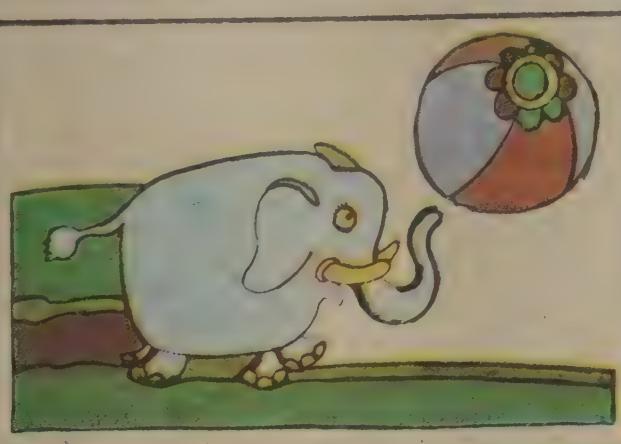
No. 2 could be a taxi being driven by a swan.



No. 3 : a dentist attempting to extract a tooth with a pitchfork.

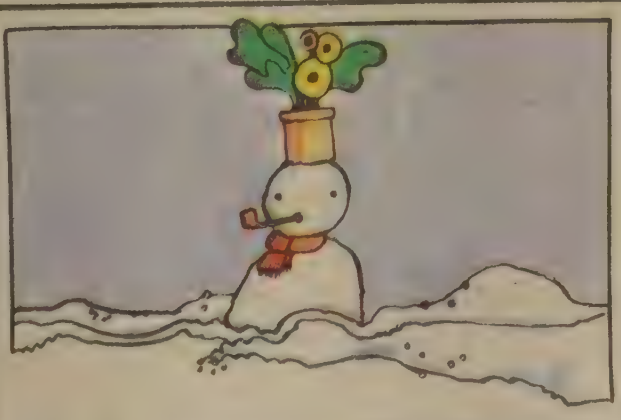
No. 4 : a sailboat with a carpet used for

No. 5 : imagine your uncle caught on a hook.



No. 6 : an elephant playing with a ball.

No. 7 : a pig with a walking stick.



No. 8 : a snowman with a flowerpot.

No. 9 : a snake made of silver.

No. 10 : a snail playing the guitar.

Having thus associated the words, you can now recite them in order.

Suppose, you were asked, what's the sixth word? You check your permanent pegs. There you are — you come up with an elephant's trunk which you quickly associate with an elephant playing with a ball. So you've got your sixth word — BALL. Right?

What about the third word? Your permanent peg tells you No. 3 is a pitchfork, which you associate with the dentist; so you remember your third word — TOOTH. The whole list can be recalled in this manner.

Your mind must be like a filing cabinet. Store all information in separate files. Then only you will know where to find what you want. To do this, tidy up the information you receive by getting rid of irrelevant material. In everything you do, whether it is reading, listening or organising — be it in the office or in your personal life — see things in their orderly logical sequence.

NUMBER-SOUND PEG SYSTEM

In this system, each number is replaced with a similar-sounding word to form an image.

1 — Sun, 2 — shoe, 3 — tree, 4 — door, 5 — hive, 6 — chicks, 7 — heaven, 8 — plate, 9 — wine, and 10 — hen.

The words must sound similar to the numbers and have good visuals which will stay fixed in your mind.

ALPHABET PEG SYSTEM

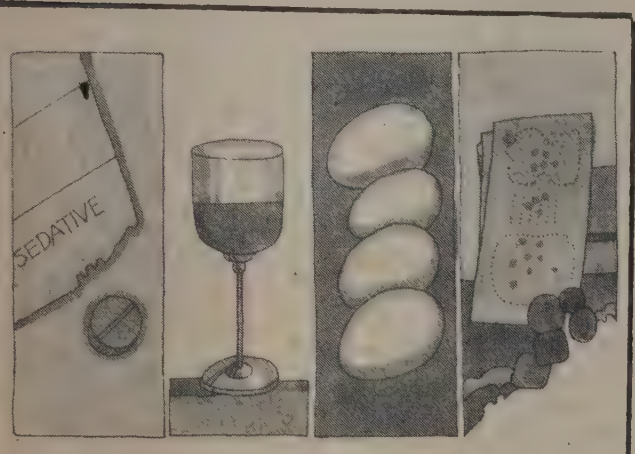
This is similar in construction to the number-shape system and the number-sound system. Here, in place of numbers, we use the 26 letters of the alphabet. To form your pegs, first select a word that starts with the *actual sound* of the letter, and which is visually outstanding. Some examples :

A — ay — ape
F — eff — effigy
K — kay — cake
L — el — elephant
M — em — emblem
N — en — envelope
O — o — opal
R — or — artist
S — es — eskimo
U — u — universe
V — we — wheel
Z — zed — sedative

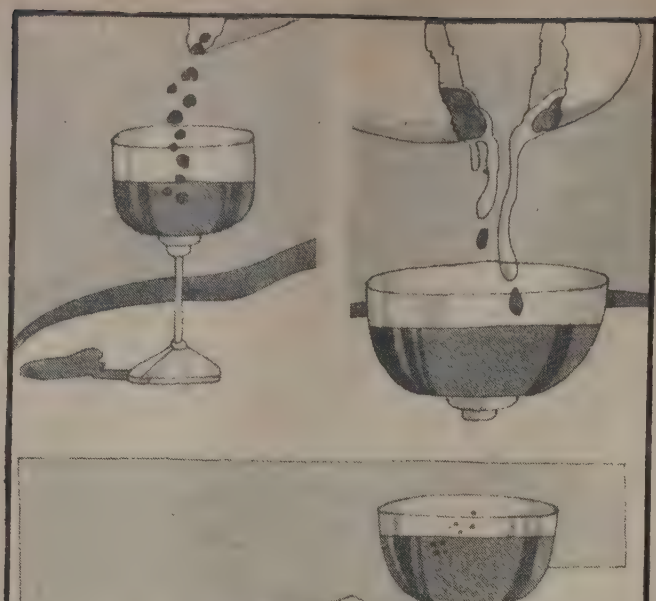
The words to be memorised can now

be associated with the permanent alphabet pegs achieving the same result as with the earlier peg systems.

You are free to use any set of pegs and to represent any number by any visual image you care to select. What is important is that one definite peg-code should be decided upon and should be made completely familiar before being put into use.



The alphabet-peg system will also aid in memorising your alphabet backwords, after you have formulated your alphabet associations such as sedative for Z, wine for Y, eggs for X, doubloon for W and so on. All you have to do is associate the pegs using the chain system and you will have no problem in remembering the alphabet in reverse order.



Thus, we could possibly link them as "a sedative in wine, mixed with an egg and sold for a doubloon". From this sentence, we get Z, Y, X, and W. We could easily work back to the letter A.

EXERCISE

Here are two sets of 10 words for you to memorise in and out of order:

*ESSAY TALENT PUBLIC PIONEER EDUCATION AUTHOR JUDGE TELEVISION ALPHABET LAKH

**INVENTOR PSYCHOLOGIST AWARD HOBBY LECTURE WIZARD TEMPER TEACHER SINCERE SERIES

Give yourself five minutes to study two groups of words using the 'pe system'. Associate two words at a time the first word from the set with the f permanent peg of your choice and so After pegging the whole list of wor give yourself some time to recall the l If you score full marks then:

Try to memorise this set of 26 words order using the alphabetical pegs.

NECK WINKING WHISTLIN SOFT VOICE WICK VEGETABL HANDS ANGRY SILENCE GUITA COOKING EXERCISE HEALT EXERTION OUTINGS CONSCIOU BUDGET WALKING CHARMIN WATER TEA NEWS WORK DRUGS COMPANIONS.

You will notice that the more sets y attempt to remember using this syste the more your capacity for retaini increases, be it study points, shoppi lists or what have you.

While you wait for the next step, for your *own* sets of permanent pegs. This w facilitate pegging anything you want remember in a relaxed and confident way

Next month:

THE HUMAN CALENDAR
REMEMBERING PLACES
LOCATING MISSING ARTICLES

IDEAS AND INVENTIONS
(Contd. from p. 31)

Cement Coating Protects Steel from Corrosion

CORROSION is a common problem everywhere, but corrosion of steel reinforcement embedded in concrete is more serious because of the greater hazards it can cause. A survey conducted by the National Buildings Organisation, New Delhi, and the Central Electrochemical Research Institute, Karaikudi, revealed that reinforced concrete roofings and reinforced brick constructions failed prematurely because of corrosion. Studies conducted on a number of coastal bridges and structures have also shown that corrosion caused their deterioration within a short span of time.

Since corrosion of reinforcing steel is due primarily to the penetration of moisture, chloride and air, preventive methods must either block such penetration or render the reinforcement passive to their action. Various preventive methods such as water-impermeable surface coatings to concrete, metallic coatings on reinforcement and inhibitor additions to concrete have been suggested. Both concrete coating and metallic coating of reinforcement present difficulties; the former is not dependable and the latter is costly. Inhibitor additions to cement slurry have been considered for economy and bonding characteristics. After various laboratory tests, a new protective coating to reinforcement, based on cement slurry and an inhibitor system, has been developed at the CECRI. The coating uses entirely indigenous raw materials. It can be applied by brushing, dipping or spraying. Brushing is easier and economical, though.

The coating does not affect the bonding strength between the coated reinforcements and concrete. This was tested by conducting standard pull-out tests (in a 30-ton Avery Universal Testing Machine). While steel reinforcement without the coat showed an average bonding strength of 20 kg/sq cm, coated steel gave a value of 22·6 kg/sq cm. Laboratory tests showed that the new coating resisted chloride, alkaline medium, sulphate and high temperature.

Field studies were also done at a number of sites in different climatic zones. Concrete cubes of 152·5 mm with embedded steel were used for such studies at Mandapam (Tamil Nadu), New Delhi, Jorhat, Bangalor Bombay and Nagpur. The coatin was used in various thicknesses an the cubes were exposed to the enviro ment for one year to four years. Tot protection with even a 13-mm coatin was observed at places like Mandapa and Jorhat. A coating of 25 m prevented corrosion at all the sites.

The new coating will be used i the pier and beams of the Hig Level Bridge across the Pamban Stra near the Rameswaram Island bein built at an estimated cost of Rs. 5· crores. The bridge will use abou 4,500 tons of steel. Being across th sea, it is subject to severe salin corrosion. In field scale, the coat ing per ton of steel reinforcemen may cost Rs. 170 to Rs. 180 which i economical.

Accelerated laboratory tests an field exposure studies at differen places thus show that the new inhibi ted cement slurry coating can satisfac torily protect steel reinforcement from corrosion both during storage an when laid in concrete under aggres sive atmospheric conditions.

K. S. RAJAGOPALAN
T. M. BALASUBRAMANIAM

[The authors are with the Central Electro chemical Research Institute, Karaikudi.]

where is the mythical 'wishing tree"?

R. Vaid

K. M. VAID

Fig. 1 *Kalpa-vriksha* of Besnagar or *Vidisha* (c. 3rd century BC)

THE question has been haunting the mind of the scholar as well as the imagination of the layman for millenia — where is the mythical wishing tree, the *kalpa-vriksha* mentioned in all our *Puranic* literature? In the story of the *amrit manthan* or *sagar manthan* (churning of the ocean), the *kalpa-drum* was one of the 14 different rare and precious items that came from the sea. The *Bhagavat Gita* describes it as " eternal, the heavenly tree which has its roots upward; . . . its branches extend both downward and upward; . . its size is so massive, none can understand where it begins, where it ends or where its roots are; . . . the real form of this tree cannot be perceived in this world."

In the Jain scriptures, where episodes from the lives of the 24 Tirthankaras are described, we find the times of prosperity as well as want are correlated with that of the *kalpa-vrikshas*. The tree abounds in several legends and folk-lores, too.

It is difficult to trace the actual origin of the myth of the *kalpa-vriksha*, but all ancient literatures describe it as an immortal tree of colossal dimensions, laden with fruits, its roots penetrating into unreachable depths, that its flowers are of an unusual shape and they have a strange aroma, and that the tree fulfilled every wish made under its boughs. So, the belief persisted, aided by charlatan interpreters, that the *kalpa-vriksha* was a tree of Indra's paradise, never seen on earth.

However, few are aware that the wishing tree has been depicted in our ancient sculptures. But, here again, charlatanism has confused the reading of the language of the stone as well as the mind of the sculptors, especially whether they were drawing from their imagination while depicting this tree or if they could have had the " real thing " in front of their eyes.

One of the earliest representations of vegetation in our sculptures is the *kalpa-vriksha* from Besnagar or *Vidisha* (circa 3rd century BC) (see Fig. 1). The base of the tree is shown encased in what appears to be a net of strong rope; above, there are bags (of money, perhaps), a large pot (containing drink) with its lid piled up with fruits, and several other items.

We can cite two other sculptures which can qualify to have depicted the *kalpa-vriksha*. The railings at Bodhgaya (circa 100 BC) enclose the space where the Buddha is said to have walked after his enlightenment. The sculpture on the railings shows a panel with the extended hands of the *Vriksha-devata* holding a water vessel in one hand, and a plate of food in the other, offering food and drink to a wayfarer (Fig. 2). The other sculpture can be found in the Ellora caves (Cave 32, Indrasabha) (Fig. 18). This is how Heinrich Zimmer, the noted authority on archaeology, has described it in *The Art of Indian Asia:* " The tree above the head of Indrani is a Wishing Tree (*kalpa-vriksha*), one of those heavenly trees that fulfil any desire instantaneously, granting, through their fruits, every wish. Such plants abound in the pleasure groves of Indra's paradise ". It is possible, there are many more sculptures with the *kalpa-vriksha* theme, but their identity may have been grossly mistaken or overlooked by scholars.

Probable earthly candidates

In all fairness to scholars of our ancient texts, it must be admitted that several of them have indeed looked for probable candidates amongst the trees found on our land to fit the legendary descriptions of the *kalpa-vriksha*. Three trees stand

Fig. 2 Bodhgaya railing (c. 100 BC): *Vriksha-devata* offering food and drink to the wayfarer

out in the annals of this search. They are the banyan, the mango and the coconut palm.

Because of its massive size and supposedly "incredible age", it has often been argued that the Indian banyan tree (*Ficus bengalensis*) is the real *kalpa-vriksha*. But, besides its massive form (not *size*), there is practically nothing of the other fabulous properties of the 'wishing tree' that the banyan can boast of. Neither does it have the beautiful flowers or the large fruits, nor does it provide food, water, or other items of the needy. The banyan starts life as an epiphyte. First it kills the host which provided it berth. It has that self-strangulating habit by which the original stem dies after some decades and it is via the pillar roots that further proliferation takes place. Also, it is not as long-lived as it is often thought to be; even the largest banyan tree in India, at the Calcutta Botanical Gardens, is just over 200 years old. And, then, the banyan, being one of the commonest Indian trees, could hardly qualify to be the "rare", "heavenly" *kalpa-vriksha*.

The next choice of a number of thinkers is the mango, because it provides the delicious fruit. There are several sculptures from Ellora, Ajanta, etc, which have been claimed to feature the mango and, therefore, a candidate for the name *kalpa-vriksha*. These claims are mostly erroneous, as we shall see later. Besides, the mango fails to qualify as the *kalpa-vriksha* on several other grounds: it offers nothing but the fruit, and that, too, for just a few months in alternate years; the mango is also one of the commonest trees in India and is not very long-lived.

The coconut palm, of course, comes very close. It is one of the most useful of all palms — every part of it is useful in one way or the other; but, then, here the resemblance ends. The coconut's stem is one of the thinnest, with a crown of a few leaves way up at the top. A weary traveller wishing for a simple thing like 'shade' will not get it. Its distribution is restricted to the coastal areas. There are no unusual flowers. The tree is very common and does not live very long.

So, failure to identify any single tree of the Indian region (which was a wrong approach) as the true *kalpa-vriksha* has perpetuated the belief that this tree of our myths is truly mythical.

Fig. 3 *Kalpa-vriksha* fair at Magliawas near Ajmer R. V

This is an error. The tree is there. Before we go on to establish its botanical identity, let's first try to understand what the word *kalpa* means. Thereafter, we can examine the proposition scientifically, without any bias.

There is one problem with our ancient texts which makes correct interpretation rather difficult: one word often conveys several meanings, and, very often, each interpreter explains it in his own way according to his understanding, rigidly, without an interdisciplinary approach. The *kalpa-vriksha* is one such example. *Vriksha*, no doubt, means tree, but the exact meaning of the word *kalpa* is elusive. We can, for example, cite four possible meanings: (*i*) *kalpa*, in mythological terms, means "one day of Brahma, a period of 4,320 millio years", but in a metaphorical sens as applied to the life of a tree, it ma mean *very long age*, say, several thou sand years; (*ii*) *kalpa* also means tha which is indestructible, and has th power of rejuvenation; (*iii*) *kalpa* als means the property of fulfilling ever wish or need; (*iv*) *kalpa* also stand for anything mythical or imaginar It is in the context of this multiplicit of meanings that we now turn to th mythical account of the *arrival* of th *kalpa-vriksha* in India.

We have said earlier that the exac origin of the *kalpa-vriksha* is unknow However, let us accept the account

the churning of the ocean — the *sagar-manthan*, one of the most well-known of our mythological lores — at its face value. It was, perhaps, the earliest offshore exploratory or good-will mission and Gujarat coast (Kutch-Kathiawar) was the launching site, Dwarka being the possible sail-off point. Krishna's period is estimated at around 2500 BC and that was the time the Egyptian civilisation on the Nile valley was at its zenith. And, in a practical sense, we could possibly interpret the *sagar-manthan* to be several circuitous voyages all round the Arabian Sea and adjacent parts of the Indian ocean. The 14 rare and precious items, in addition to *Amrit* (*Shri*, *Mani*, *Rambha*, *Varuni*, *Sudha*, *Shankh*, *Gajaraji*, *Dhenu*, *Kalpa-drum*, *Shashi*, *Dhanu*, *Dhanvantri*, *Visha*, *Baji*), could have been items picked up from the various lands the voyagers might have touched upon.

We are told the *kalpa-vriksha* was one of these 14 things. In other words, this tree did not exist on the Indian soil, but was brought from some island situated in the sea or from some country across the sea. Therefore, speaking in phyto-geographical terms, we can say that this tree is an "exotic" in India. This is a very crucial point which, in one stroke, eliminates the possibility of any of our indigenous trees qualifying for the honour. A search has, therefore, to be made in the neighbouring western (African) countries for a tree that might come close enough to the specifications prescribed for the *kalpa-vriksha*.

That the African land in the west and the Indian land in the east were in contact with each other is fairly established: recent excavations by the Archaeological Survey of India have discovered a sizeable dockyard at Lothal (circa 2300 BC) which was the berthing place of ships voyaging between India and countries in the west — Arabia, Egypt, Ethiopia, etc.

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(Above) Fig. 4 A full-length turban (9 metres) goes round the trunk only once

(Left) Fig. 5 The worshippers circumambulating the tree despite the rains

The earliest historical reference to trade between India and African countries occurs in the "Periplus of the Erythrean Sea", a guide-book to the Indian Ocean, written in Greek about AD 60. It describes how the ships were fitted out from Arrica (Cutch, Kathiawar and Gujarat) and Barygaza (Broach) to bring to the market towns of East Africa wheat, rice, ghee, sugar, cloth, etc. These were traded in the Arabian ports for gums and incense, in the African coastal countries for gold, and in

Fig. 6 *Urdha mulam adhah sakham* truly applies to the African baobab, as seen in leafless condition (Photo from Tanzania, by the late Mr. N. R. Nair)

Sri Lanka and Malabar for pepper and cinnamon. We can easily visualise the route — a circumnavigation of the entire ocean (of which the *manthan* or ' churning ' could be a metaphor?). There were even Hindu settlements on the north coast of Socotora. Socotora was known to Indian sailors even before the discovery of the monsoon winds by Hippalus in AD 45. (In the *Puranas*, Socotora is mentioned as *Sukhadhara;* the source of the Nile as *Kusa-dvipa;* Zanzibar, the island of shells, as *Shankha-dvipa;* and *Salmali-dvipa* as that part of tropical Africa which borders the Indian Ocean on its west, including Madagascar. Important references in this context are: Rigby, 1843: *Proc. Bombay Geog. Soc.;* Speke, 1863: *The Discovery of the Source of the Nile;* Panikkar, 1962: *India and the Indian Ocean;* Pusalkar, 1965: The *Puranas: Indian Inheritance;* Ali, Musafar: *The Geography of the Puranas.* In the Puranas, river Nile is known by the name of ' Krishna ' and the region between the central lakes and part of Tanzania is referred to as *Chandrasthana*, otherwise known as the " Mountains of the Moon ", or Ruwenzori Mountains.)

The puranic name, *Salmali-dvipa*, can be explained easily. *Salmali* is the Sanskrit name for the common semal or red silk-cotton tree, *Bombax ceiba* (*Salmalia malabarica*), found in India; the family (*Bombacaceae*) to which this belongs is called *salmali-vamsha* in Hindi. The tropical regions of Africa contain the largest trees of the *salmali-vamsha*, the African baobab (*Adansonia digitata*).

The baobab extends from the extreme west coast of Africa to the east coast, and nearly 20° north and south of the equator; in all, there are about seven different species of the baobab present in the vast continent including, Madagascar (whereas in India we have only two species of *Bombax*, of which the semal is the only one common, extending right up to the north).

In its grotesque appearance as well as in its manifold uses, the baobab is truly the most fantastic tree in the world. Its crown spreads to nearly 50 to 60 metres in diameter, and the massive branches are supported on a single, solid trunk which is veritably awe-inspiring — measuring about 30 metres in girth in many cases (in some rare instances, the girth may be as much as 80 metres). Curiously, the tree's height never matches its girth proportions: the trunk may abruptly taper and branch off from a height of five to six metres, and the entire tree may not be more than 20 to 25 metres in height. Livingstone, the great missionary-explorer, had called this tree the " eighth wonder of the world ". Now, if we could admit the historical facts of the past, and the

Fig. 7 Baobab depicted on a Zambian postage stamp

related mythology, it would bec clear that the voyagers from In during their sojourn along the Afri coast (as part of the circumnavigat voyage) might have been wonc struck by the look as well as the purpose properties of this sacred and might have brought it to In as the *kalpa-vriksha*.

The foregoing r read like a sweeping statement. Th fore, we shall now proceed to st the taxonomical details of this and evaluate them against the scribed qualities of the *kalpa-vri* in our ancient literature.

The baobab's most striking pearance is when it is leafless condition that lasts nearly six mor of the year; the bare branches like roots sticking out in the air, if the tree has grown upside-do There is an African legend wh says the baobab was initially plan by the Creator in the Congo ba but the tree complained about excessive dampness. The tree given a new site on the high slo of the Ruwenzori Range (' Mount of the Moon '; *Chandrasthana* in Pu nic literature). Yet, the tree wa happy. Angered by the tree's const wailing, the Creator plucked it and hurled it into Africa's arid s the tree landed upside-down. Tak look at any baobab tree, or the depicted on Zambia's postage sta (Fig. 7), and the legend seems to ha come alive.

Now, a similar description of tree can be found in the *Bhagavat G* though Krishna does not specifica name it as the *kalpa-vriksha* (we sh arrive at the proof by inference).

urdhvamulam adhahasakham
asvattham prahur avyayam (Ch. 15

(" They speak of the imperishal *asvattham* tree as having its root abo and branches below "; interestingly similar description occurs in *Ka Upanishad* (Ch. V:1): " With ro above and branches below, this wor tree is eternal.")

Now, *asvattham* has been translat as the common banyan by mo authors. This is an incorrect inte pretation. In certain parts of Afric the baobab is also called *banian.* fact, we can cite several reasons wh the banyan (*Ficus bengalensis*) cann be *asvattham.*

Take the roots. Centuries ag Adanson (after whom the baobab ha been named) had measured a tre whose main trunk was four metre high with a circumference of 2 metres; the main root was 33 metre long. Because of the scarcity of wate in these desertic regions, the roots the baobab stretch out of proportio

g. 8 Water stored in this hollowed baobab ee is being drawn out in skin-buckets and old to traffic on a highway in Sudan (Photo: afaala Basit, Sudan)

Fig. 9 In times of severe drought in Africa, elephants tear apart the trunk of the baobab to suck water out of its fibre (Photo by the late N. R. Nair, taken at Kenya)

as baobab unless it is pointed out to them. In certain remote and far-flung places in India where occasional baobabs still stand, the local people know them as heavenly *kalpa-vriksha*, *parijat*, etc, and festivals are held to worship them as the " wishing tree " (see Figs. 3–5).

It does not require any great stretch of imagination to see the baobab in the light of the several meanings of the word *kalpa:* it is 'indestructible' and 'eternal' in the sense of being long-lived. (Adanson calculated the age of some African trees of nine-metre diameter and placed them at 5150 years.) It is also 'imaginary' in the sense that, few, very few, have ever seen this tree in India, and those who have, can hardly recognise it. Perhaps the largest tree in India is at Prayag (Allahabad) (Fig. 15), and even the *District Gazetteer* (1968, p. 381) mentions: " The tree has not been identified botanically ". The local people call it *vilayati imli.*

Fig. 10 A large baobab tree in Rameswaram, blown down by cyclone 20 years ago, continues to flourish lying on the ground by putting forth new roots as seen here

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) the height of the tree, about 50 netres deep and 90 metres sideways. Compare this with the sentence from ne *Bhagavat Gita:*

adhas ca mulany anusamtatani (Ch. 5:2)

(" This tree also has roots going eep down.")

The banyan qualifies neither for ne *urdhamulam* description, nor for the *dhas ca mulany anusamtatani.* For, the ormer calls for a single massive stem, ne latter, for deep roots; the banyan, ve know, has hundreds of pillar roots vhich support the massive spreading ranches, but the main stem dies away self-strangulated) after a century or o. Besides, if the tree mentioned by Krishna were the banyan or the eepal, both common trees, why do we ncounter this description in the ubsequent verse?

na rupam asye 'ha tatho 'palabhyate
na 'nto na ca 'dir na ca sampratistha
(Ch. 15:3)

(" Its real form is not thus perceived ere, nor its end nor beginning nor oundation. . . .")

The question arises, if the baobab omes closest to fit the puranic descriptions, why did our commentators nd translators of ancient texts fail to erceive the link? The answer could e that, the search has all along been confined to indigenous trees only; what's more, the interdisciplinary approach in botany-archaeology-mythology-phytogeography has been totally absent. There is also the fact that, there are not that many baobabs in India, and even now, many persons fail to recognise a tree

Fig. 11 Baobab fruits growing on a tree in Bombay R. Vaid

And, the baobab does qualify as a fulfiller of wishes, if we are prepared to understand the word " wish " in the context of the *basic necessities* of the inhabitants of remote areas some millennia back. It is this last aspect that we shall now look into in some more detail.

The baobab plays an important role in the economy and life of many African tribes. So much so that certain regions of Africa would have remained uninhabited had there been no *tebeldis* (as the baobab is known there). Every single part of the tree is put to use there and the tree is never allowed to be cut.

Consider the stem. The wood is light and spongy and is used for making floats, rafts, insulating boards, etc. The trunk, a single stem, attains girths of about 30 to 50 metres, and being soft inside, sizeable cavities are dug out by the people to form living rooms. Livingstone described one such hollowed trunk as large enough to accommodate 30 sleeping persons (nearly 45 square metres of floor space). Livingstone had carved his name on one such tree; with his name found intact after nearly a century, the tree has now been declared protected.

In the border regions of Kordofan, there are no wells for perhaps hundreds of kilometres, and in the dry season, the only sources of water are the hollow trees called *banian* or *tebeldi* which, on an average, hold about 5000 litres of water. These trees have to be prepared carefully for use as reservoirs and each family owns certain trees for its own use as well as for the sale of water to travellers in the Sahara (Fig. 8). Some old trees begin to split at the top bifurcation of huge branches and the hollow thus formed collects rain water. Elephants, giraffes and some arboreal animals make use of the water in times of scarcity (Fig. 9). And, hollow trunks are also used as silos for storing grain.

The fruit is the most useful part of this tree and forms the principal item of food (though the leaves, too, are eaten as vegetable). The plentiful fruits come in various sizes and shapes, ranging from the rounded to the gourd-like, from 15 to 45 cm long, woody when ripe, and covered with a greenish-yellow fuzz. The mealy pulp has a pleasant flavour and acid taste of cream of tartar. It can be knea into dough or can be used with to make a nourishing gruel ca *rooy*. It is mixed with daily food reduce perspiration and makes excellent cooling *sherbet*. The pul also used to curdle milk. Baboons other monkeys are very fond of fruit, which explains the baob other name — ' monkey-bread tr The pulp is also used as a diapho against fevers and to treat scu diarrhoea and other stomach ments. The leaves are used to t kidney disorders and the gum obtai from the tree is used to cleanse sores, especially in camels. The ro fruits are burnt, the leys boiled v palm oil and used instead of soap

Embedded in the pulp are m kidney-shaped hard seeds which pounded and eaten as food in time scarcity or regularly mixed with m of millet. A non-drying golden-yel oil of agreeable taste called *fony reniala* is expressed from the seeds

The baobab is also a source of quality honey. Wild bees manage perforate the soft wood and loc their honey in the holes. Even oth wise, in many parts of Africa, hollow trunks of baobabs are e ployed for bee-keeping. The ba too, is used to make fibres. The in bark is peeled off in long, thin she which, after cleansing with wat can be used directly as coarse fabr or, as in Senegal, the fibre can woven into cloth. It is also ma into strong ropes, sackings, ho girths, elephant saddles, fishing ne strings of musical instruments a even paper of very high streng Africans remove the bark from t living tree, again and again, un it is completely stripped on the low portion. Then the tree grows a fre layer of bark and rejuvenates, witho suffering the slightest damage.

Fig. 12 Flower and bud of the *kalpa-vriksha* of Mangliawas. Compare the leaf-pattern w that shown in the Ellora sculpture in Fig. 18

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Fig. 13 This baobab tree at Baralia (UP) is worshipped as *parijat*. The author is seated third from left with other botanists from Lucknow

Fig. 14 This photograph of a colossal baobab growing at Karwand, Buldana District, was taken in 1898. The tree then measured 13 metres around; today, the girth is about 16·5 metres (Karwand is not very far from Ajanta-Ellora)

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The flower (see Fig. 12) is, indeed, very unusual — large, about 15 cm across, with pure white petals, and hanging by a stalk about 15 cm long. The shaving-brush-like big bunch of stamens formed at the end are a favourite plaything of the bush-babies. The flowers open at night and the process — from the ball-like bud to an exquisite flower of the purest white — takes only an hour or so. Their beauty lasts only for the night and by morning the petals become limp. Curiously, while on the tree, the flowers give off a sweet fragrance, but when plucked, they begin to emit a very unpleasant smell. (Incidentally, the puranic descriptions of the flowers of the *kalpa-vriksha* in Indra's paradise do indicate such a 'pleasant-unpleasant' dichotomy in the flower's fragrance depending on the nature of the beholder's thoughts!)

Besides fulfilling the daily needs, in some regions of Africa, the baobab has been put to some not so earthly uses. For example, read this passage from the *Botanical Magazine*, London, 1828: "The tree is subject to a particular disease, owing to the attack of a species of fungus, . . . and renders the part so attacked as soft as pith. Such trunks are then hollowed into chambers and within them are suspended the dead bodies of those who are refused the honour of burial. There they become mummies, perfectly dry and well-

Fig. 15 Giant baobab on the east bank of the Ganga at Jhusi (Prayag, Allahabad). This tree has been mentioned in the *puranas* and also Bashir-ud-Din wrote about it in AD 1310. (Right) Closer view shows the massive trunk (more than 18 metres in girth at the base); the exposed root close to the stem is about 1·2 metres thick and stretches some 30 metres

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preserved, without any further preparation or embalmment, and are known by the name of *guiriots!*"

And, more than any other known plant on the earth, it's the baobab that keeps serving or benefiting generations upon generation of people living near it, because of its incredibly great age. One could say the tree is almost indestructible, destroyed only by wild elephants in times of severe drought. They tear apart the tree with their tusks and chew the fibrous bark for water and large quantities of calcium it contains. The thick fibrous bark is remarkably fire-resistant, and even if the interior is completely burnt down, the tree continues to live. Even where a tree is blown down by a storm, it continues to flourish lying on the ground and puts forth new roots (see Fig. 10).

The *kalpa-vriksha* in India

The commonly held belief amongst botanists is that the

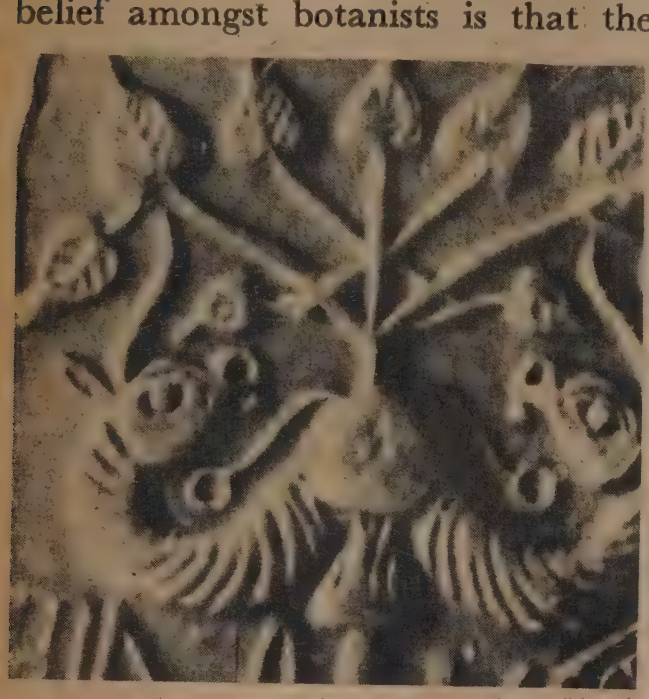


Fig. 16 Seal from Mohenjodaro showing peepal leaves complete with mid-rib and secondary veins (c. 3000 BC)

baobab came to India from Africa with the Arab traders some time in the 7th or 8th century. I feel this is a misconception born out of ignorance about our ancient history. It is almost an obsession with us that, all that we find as exotics in our country must have been brought by foreigners — the traders or the invaders. Little do we realise that Indians themselves have been pioneers in this campaign in times much earlier than hitherto considered.

No doubt the baobab is a native of Africa, but the most convincing evidence about its very early introduction to India is that there are several remote and sacred places connected with Indian mythology where giant-sized trees (though not as gigantic as the African trees) of the baobab still exist in small numbers. They are strikingly outlandish in their environs, but the people in their simple faith have accepted the belief passed on by their ancestors that these trees were brought from Indra's paradise; some have been named *kalpa-vriksha*, some have been called the *parijat*. These trees are located near places of pilgrimage, archaeological sites, ancient temples and monuments — from Rameswaram at the southernmost tip of India to as far north as the latitude and climate would permit their survival.

We find these trees mentioned in the ancient Hindu, Jain and some Buddhist literature, too. Added to it are the sculptures of the ancient temples, rock caves, viharas and stupas. Sadly, in all such instances, the trees' identity has been grossly mistaken — either they have been labelled as the 'imaginary' *kalpa-vriksha* or branded as the commonplace banyan or mango. It would suffice to cite two examples.

The sculpture shown in Fig. 1 (now located at the Indian Museum, Calcutta) is from 3rd century Besnagar or *Vidisha* in Madhya Pradesh, not far from Sanchi. Ananda Coomaraswamy, the celebrated art historian and critic, believed this sculpture must have been the *dhwaja stambha* of a temple of Kubera and represented the mythical "wish-fulfilling" tree. Coomaraswamy thought the tree to be a banyan; other authors have simply followed suit.

In the other instance of the sculpture from Ellora (Cave 32), authorities like Zimmer and Coomaraswamy have gone only so far as to say that the tree above the head of Indrani is a 'wishing-tree'. Certain recent authors, however, have identified the tree as the mango. Now, this is an interesting point. Both the *Vidisha* and the Ellora sculptures have been called the *kalpa-vriksha*, and yet botanically, the former has been treated akin to the banyan and the latter to the mango.

A close examination of the *Vidisha* sculpture will reveal that what looks like leaves is *not* the foliage. The banyan has leaves approximate near the ends of branches, ovate, mostly obtuse, with three to five basal nerves and four to six pairs of secondary nerves on the midrib: There is no reason to think that what has been depicted on the sculpture was a stylised version of the banyan leaves: in all Indian sculptures with tree motifs, leaves have invariably been shown with their proper morphological character, as far as possible, complete with midrib and secondary nerves. The Mohenjodaro seal, shown in Fig. 16, is a case in point. In the *Vidisha* sculpture, the position of the 'leav is neither approximate near the e of branches, nor are there any ba nerves or secondary nerves. A the other adjuncts — the vessel, bag, the piled up fruits, etc — ha no correlation with the banyan tr What appears to be 'leaves' m actually be the *fruits* of a tree in leafless condition. Their chiselli is more than 2·5 cm deep. Even fr the photograph we can make out t roundness of the fruits and not t flat iso-bilateral form in which t leaves are always depicted.

I examined this sculpture recen at Calcutta and found that so lanceolate-shaped leaves (like t mango's) have been shown comple with mid-rib, arranged over one the pots. Amongst these adjunc there is a small club-like article which designs perfectly resembli the bud with long stalk of the baob are shown. The only points which in favour of the banyan are the pa of globular fig-like things at the ti of some branches.

The articles placed at the ba represent the various uses of th baobab described earlier (includin the rope-net). Interestingly, the vesse as it is depicted, is of the same desig and proportion as the *deg* common used by Muslims in Arab countri (and in India, too) at the time of I and other ceremonies. This figur perhaps, has some characters of th baobab, and some of the banyan.

Let's now turn t the Ellora sculpture (Fig. 18). Th points to consider are the two larg fruits and about eight bunches c smaller fruits; a monkey trying t have a go at a small bunch; peacock perched at the top corners; the lio on which the goddess is sitting. Coul this tree be the mango, as som

Fig. 17 Mango tree laden with fruit. All fruit are of the same size. They have no resemblanc with the fruits in the Ellora sculpture shown i Fig. 18

Fig. 18 Ellora Cave 32. The tree above the head of Indrani is variously described as *kalpa-vriksha* or mango. Note the monkey (black arrow), the lion and the peacocks. (Courtesy: Archaeological Survey of India)

authors have claimed? No. We have four distinctive features to prove our point:

i) Mango is a seasonal fruit and that, too, a tree will bear fruit in alternate years. Besides, all the mangoes on a tree are of the same size and their arrangement is quite different from that shown in the sculpture (see Fig. 17).

Fig. 19 Fruits of baobab resembling the two large fruits shown in the Ellora sculpture. Baobab fruits come in many different shapes and sizes

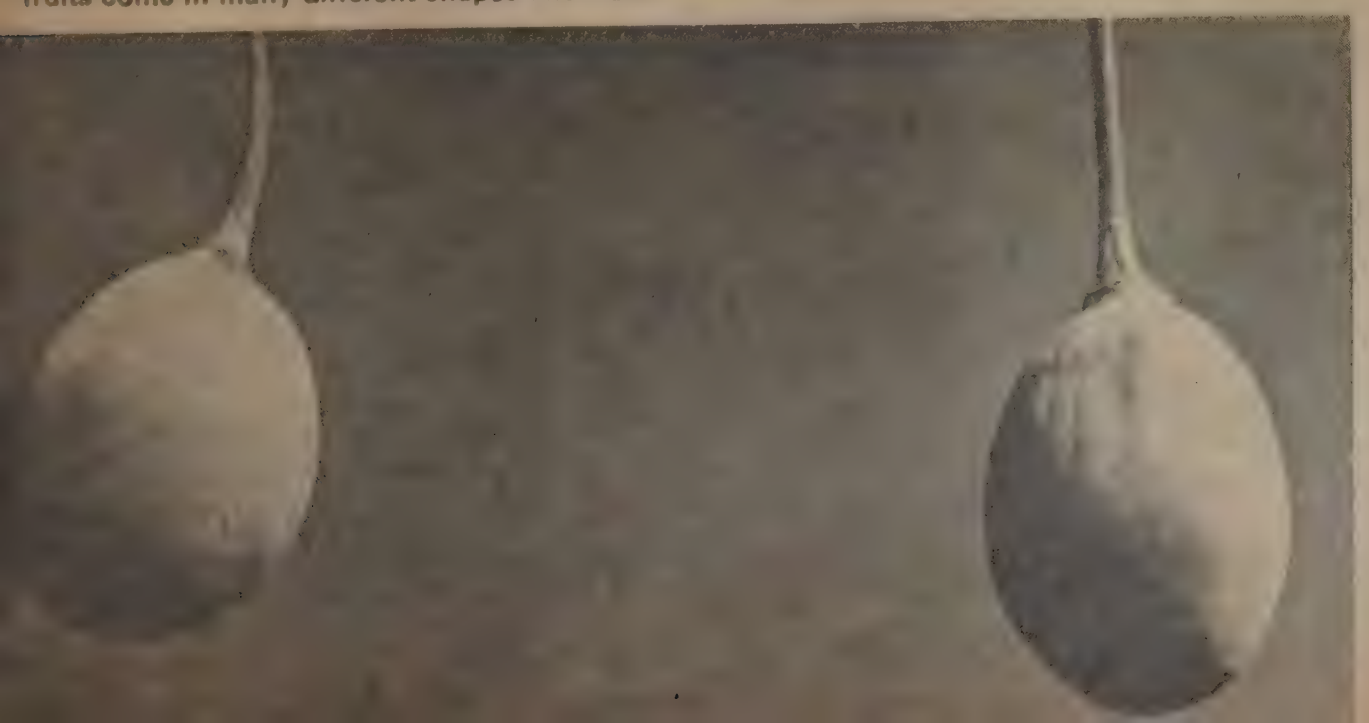


Fig. 20 Before dawn, a peacock seen sitting atop the *kalpa-vriksha* of Mangliawas (negative print from a colour telephoto)

In the case of the baobab, however, large-size fruits from the previous season keep dangling from the tree, while with the flush of new leaves around May-June, bunches of egg-size buds supported on long stalks appear near the tips of branches and on smaller shoots. After a short spell of flowering, the tree is laden with fruits of small size, in bunches of a few fruits together. The sculpture shows the tree in exactly such a stage — with both large older fruits and bunches of smaller new fruits.

ii) The monkey depicted in the sculpture is significant. Young fruits are greedily eaten by monkeys (the baobab is also known as the ' monkey-bread tree ').

iii) In the vast savannahs of Africa, lions can be seen sitting in the shade under the giant baobab trees.

iv) Wherever the baobab trees are grown in India, peacocks can be seen sitting on the topmost branches in the earliest hours of the morning (see Fig. 20).

It is futile to search for any indigenous species of trees which have fruits of such different sizes growing on the same tree. Curiously enough there are a handful of some very colossal antique baobabs located in the Ajanta-Ellora range (a Karwar and Buldana district) no very far from the caves. These tree are larger than the largest indigenou tree of that area, but being remote their presence is not known to ever many of the local inhabitants. No one can tell for certain who planted them when and for what purpose. Possibly they had been brought by the ancien voyagers from lands across the Ara bian Sea as the ' wish-fulfilling tree ' and thus inspired our ancient temple sculptors. In the times that followed and the upheavals that took place in Indian history and culture, the rea

Fig. 21 Mortal remains of a *kalpa-vriksha* supposed to have been planted by the Pandavas near Tilpat. It collapsed into a heap of wood and fibre in 1963-64

identity of these trees in the sculptures got lost, and, subsequently, they came to be regarded as purely mythical trees.

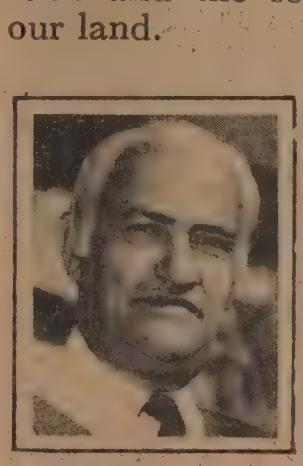
We have a large number of baobabs growing in various places in India — Andhra Pradesh, Pondicherry, Daman, Bombay, Mandu near Indore and several other places in Madhya Pradesh. Some can be seen in Uttar Pradesh: near Lucknow, Allahabad Garden, Etawah, etc. In all probability, these had been brought by traders — whether Arab, Portuguese or French. But some trees are more ancient, for example, at Jhusi-Prayag (Allahabad) and Barulia (Barabanki) in UP, at Mangliawas near Ajmer, at Rameswaram, and a few other places, which are worshipped as the *kalpa-vriksha*.

It has been suggested that we could possibly establish the antiquity of these trees to a time before the arrival of the Arabs by estimating their age by carbon-dating. But carbon-dating has its own limitations where baobabs are concerned. After a few centuries, the trunk becomes hollow from the centre, so that the initial core is not available for scientific study. The oldest piece of wood obtainable from a tree which has lived for a few thousand years may thus show very little age. This is why carbon-dating results of some trees in Africa have shown their age to be around 1,000 years or so.

I have made one such attempt with the remnants I had found at Tilpat (near Gurgaon) of a tree supposed to have been planted by the Pandavas; the tree had collapsed into a heap of wood and fibre in 1963-64. Pieces sent to the Birbal Sahani Institute of Paleobotany Radiocarbon-Dating Laboratory at Lucknow have been found to be 400 years old. Now the point is, the remnants found at Tilpat (Fig. 21) were invariably of the surface part, possibly the bark. To get the exact age of a tree (provided it is not hollow), one would have to get core samples from the deepest interior. If a tree has a girth of, say, 18 metres, one would require sophisticated boring equipment of more than three-metre length. We don't have such equipment at hand now.

Maybe we can hope to date some of our oldest baobabs in the near future.

An intimate study of the baobab in India, in time and space, is likely to upset the traditionally accepted picture of the ancient era embodied in the mythology, in the puranic texts and the sculptural remains of our land.



K. M. Vaid (54) is Senior Research Officer in the Botany Branch of the Forest Research Institute, Dehra Dun, where he has been working since 1948. His special areas of interest are taxonomy, flora of the north-western Himalayas, and identification of tree-themes in Indian archaeology. His article on the bamboo appeared in SCIENCE TODAY last month.

Mr. Vaid is also a well-known photographer of Indian flora and his colour photographs have appeared in various publications including the *Wealth of India* series and Indian postage stamps.

IN LIGHTER MOMENTS

HILBERT, the mathematician known to all quantum physicists, was perhaps the most absent-minded man ever. He was a great friend of the physicist James Franck. One day, walking along the street, Hilbert met Franck and said, "James, is your wife as mean as mine?" Franck was rather taken aback by this statement and didn't quite know what to say. "Well, what has your wife done?" Franck asked. And Hilbert went on, "It was only this morning that I discovered quite by accident that my wife does not give me an egg for breakfast. Heaven knows how long that has been going on!"

* * *

THOMAS A. Edison, never a social lion, one day found himself at an unusually boring affair and gradually worked his way towards the door in order to make his escape at the first opportunity. At this point his host came up and said, "It is certainly a great honour to have you with us, Mr. Edison. What are you working on now?"

"On my exit", said Edison.

* * *

ONE day the phone rang in the home of Robert A. Millikan, the famous physicist. Mrs. Millikan went to answer the phone, but the maid had already picked up the receiver. Mrs. Millikan heard her say, "Yes, Ma'am, this is where Dr. Millikan lives, but he ain't the kind of doctor that does anybody any good."

* * *

WHEN the atomic bomb was being developed in the utmost possible secrecy at Oak Ridge, Tennessee, the workers — most of whom had no idea what it was all about — often explained to questioners that "this is where the front ends of horses are made. Then we ship them to the Pentagon for final assembly".

PREM CHAND JAIN

ETHOLOGISTS have to be cautious not to interpret in terms of human behaviour the activities of the animals they study. For example, statistically it has been found that geese pair for life. However, Konrad Lorenz found that his records showed too many broken marriages among these birds. When he remarked about this to his assistant, Helen Fisher, she promptly retorted, "Well, what do you expect? After all, geese are only human".

* * *

HENRY David Thoreau was so enthusiastic and devoted a naturalist that Clifton Fadiman used to say about him, half in admiration and half in envy, that he could get more out of twenty minutes with a chickadoe than most men from a night with Cleopatra!

B. F. CHHAPGAR

BRAIN TEASERS

WHAT'S HER AGE? A clever but truthful girl, on being asked her age, evaded a direct answer by saying: "Twice the product of the digits of my age falls short of my age by one".

How old was she?

N. A. JAGIANI

(Solution next month)

Solution to last month's Brain Teaser

The great bank robbery

If Ramesh got X rupees, then Iqbal got 3 X, Robert got 6 X and Dileep got 8 X. Now the number 99,999 is divisible by 3 and not by 2, 5 or 7, so is the difference between 6 X and 3 X.

In the case of other differences such as $3X - X = 2X$, $6X - X = 5X$, $8X - 6X = 2X$, when these are equated to 99,999, we get a fractional value of X. But remember, only currency notes were stolen. Hence, $6X - 3X = 99,999$ or $X = 33,333$. Robert the youngest, got $6 \times 33,333 =$ Rs. 1,99,998 and Iqbal, the eldest, got $3 \times 33,333 =$ Rs. 99,999.

DEVELOPING SCIENCE FOR DEVELOPMENT

The argument that scientists' job is to do only research is an escape route devised by clever scientists

Y. NAYUDAMMA

DEVELOPMENT has been the goal of all societies throughout history. Until recently, development meant ndustrial and economic growth. It vas measured by the rise in the per-apita income or the rapid growth of ndustrialisation.

Of late, however, it is increasingly ealised that development is not just growth, but growth centred around nan — for him to live in harmony vith his environment with a sense of values of human dignity, and with elf-reliant and self-confident attitudes. Development is an integrated whole. t does not start with goods; it starts vith people and their education, organisation and discipline. Without hese three, all resources remain atent, untapped and potential Schumacher).

If development is the goal, technology is the tool. Technology is mankind's main enterprise today. And we cannot escape from its accelerating effect and massive impact on our outlook, life-style and social, cultural, political and economic structures.

We must now differentiate between science and technology. Science's aim s to understand nature and things. The aim of technology is to produce goods, offer services and meet the present and potential human needs in these terms. The greater a nation's capacity to generate, transfer and utilise technology, the faster is its growth. While science is universal, technology is not. Technology is culture-specific, resources-specific and should suit the native genius of the people and meet their needs. Science is to be judged by its excellence, technology by its contribution to social and economic development. Science and technology thus together become catalysts for growth and propellants for progress. Here we will use the word 'science' to cover both science and technology.

Even today, some leaders honestly believe that science, technology and research are social overheads like ornaments. Some split hairs about basic and applied research and say that a developing country should stick to only applied research as it cannot afford the luxury of high-cost basic research. But what is 'basic' today is 'applied' tomorrow; and only basic research can produce breakthrough technologies. There are some wise men who tell us that even applied research is not needed — if we can buy or import technology, it also means buying time. They often cite the example of Japan to show how it has prospered by importing technology. What they conveniently ignore is that Japan spends for every $1 it spends on technology import, an additional $7 in associating a local research institution to select, adopt, improve and resell that technology. This is not done in India. A country must first build its own indigenous technological competence and self-reliance even to assess, select, buy, adopt, assimilate, and even improve, a technology. Import should thus be a springboard for self-sustaining development. Self-reliance is not necessarily self-sufficiency. No country is self-sufficient in every field of science and technology.

Lacking this basic technological infrastructure, technology import could be indiscriminate. And past history has shown that indiscriminate import of technology is highly harmful. As Roger Revelle puts it, "much Western technology is designed to be capital-intensive and labour-saving and as such, it fits poorly with the factor endowments of many developing countries. Western technology is simply irrelevant, and it is often downright harmful, for example, technological substitutes for natural products. Much of the Western technology is energy-intensive, designed for use with cheap and abundant energy". And according to Schumacher, "poor countries slip — and are pushed — into adoption of production methods and consumption standards which destroy the possibilities of self-reliance and self-help. The results are unintentional neo-colonialism and helplessness for the poor."

Fortunately, India has built a strong infrastructure for technical training, for research and development and for technology competence-building. It has the third largest scientific and technical manpower in the world. Significant technological advances have been made in survey, exploration, exploitation, conservation, management and better utilisation of natural, earth and ocean resources. The impact of science is well reflected in substantial increase in agricultural and industrial production, and also in the fields of transport, design and manufacture of machinery, public utility services like roads, buildings, atomic energy, electronics, space, chemicals, etc. Most of the consumer products are made in India. Indian technologies are now exported.

A legitimate question

One can now legitimately ask what does all this mean to the common man? How has it improved his living conditions? The fact is, the impact of all this development has not been felt by the majority of our country men. Gandhiji said, "India lives in the village". But when will the wind of change reach these far-flung villages? The fond hope that by building laboratories, recruiting intelligent researchers and giving them funds and facilities, science would automatically interact with society has not materialised.

Take my own village. I still have to walk over a mile before I reach it. There is no road. Electricity came only a few years ago. Sanitation, drinking water, medical facilities and recreational facilities are still meagre. I do, however, admit that there has been a good deal of development even in the villages, maybe, in spite of

BETWEEN BASIC AND APPLIED RESEARCH

For purposes of training, I would support basic research in all areas. But concentrated efforts and funds should be devoted to selected areas. The criteria would be: (*a*) centered around a brilliant person; (*b*) related to natural endowments—for example, human genetics, fermentation, population control, molecular and cellular biology, etc; and (*c*) where competence already exists.

The CSIR policy in this regard would make this clear. In funding research fellowships, 66 2/3 per cent of the money goes for open-ended research if it is an MSc degree holder going for PhD, to learn the basics of basic research. For post-Doctoral fellowships, 66 2/3 per cent will go for oriented basic or applied research and 33 per cent for open-ended research. In CSIR laboratories, basic research is supported up to 15 to 30 per cent, depending upon the laboratory, for CSIR is an industrial research laboratory. If it were IIT, or any other educational institution, I would support 66 per cent of the funds for basic and 33 per cent for applied research.

Y.N.

ourselves. The radio, the newspaper and some other amenities are also within the reach of the villager. But there is much more to be done to meet the minimum needs of all the people and the general rising expectations. Besides, much of the planned development is planned by the urban elite. It is reflected in simple things like Coca-cola being available in villages but not drinking water. True development would mean that everyone is given an opportunity to realise his potential — to stand on one's own legs and meet one's basic demands.

This should prompt some serious thinking on how to develop science to serve the needs of these people. Science must be relevant and percolate to these people and involve them in the process of development. This calls for organisation and management of science towards this end. I am aware that the word 'management' is a red rag to some. They argue that science should be for science's sake; that science cannot be managed; that research cannot be made to order. Management is to manage, not to order. The role of science management is to provide an environment conducive to creative and innovative endeavour and to press the new knowledge, tools, techniques and technologies to serve the needs of the people.

Two approaches

Two approaches have been evident in organising research in India. The first approach is seen in the building of CSIR's (Council of Scientific and Industrial Research) chain of national laboratories — recruiting researchers from the universities in the absence of an industrial culture, conducting research, building indigenous technological competence and persuading industries to use it. The other approach is that used by Dr. Bhabha in the Atomic Energy Commission (AEC) — identifying an individual of merit, building an institution around him, buying technologies and engineering services where needed and building captive commercial plants, and completing the total technology spectrum. This is an "all-inclusive" model as compared to the "all-exclusive" model of the CSIR (Ward Morehouse).

The emphasis on institution-building around 'man' contributing to the success of the AEC is much overplayed. The power of Bhabha's personality, his strong connection with the seat of authority, and, above all, the specific goal-oriented research, together with the "all-inclusive" approach — setting up captive plants — have much contributed to this success. The CSIR, unlike the AEC or the Indian Council of Agricultural Research, is concerned with a wide range of scientific disciplines, some totally unrelated. The CSIR is also not allowed to set up proving plants. It has to persuade the industry to take risk in utilising laboratory technology from foreign commercial firms.

Building an institutional structure around a man has its own limitations. An individual-oriented, "lone-wolf" type of research may or may not be relevant to society's needs. Also, how many individuals can be left alone and provided with scarce resources without expecting any social returns? The advanced schools, set up by the University Grants Commission, centered around talent scientists have not proved so successf When the leading individual leav the whole infrastructure collaps locking up, if not wasting, scar resources. There is also a possibil of a high degree of inbreeding such a system. However, it cannot denied that it is one man that lea others follow. Such leaders and cre tive geniuses should surely be l alone, providing them all facilities a expecting no immediate returns. Ho many such geniuses do we have?

In any case, one of the maj lessons to be learnt from post-Wor War II development is, regardless whether it is big science or industri research, it is the team activity — multi-disciplinary task force approa — that pays rich dividends.

Let us take the CSIR as an examp and discuss how research in an organ sation like this can be made releva to the needs of a developing count of India's size and complexity. Th needs certain pre-requisites. The are: (1) the desired social objectiv for development and identification people's needs; (2) translation needs into technological tasks an matching the tasks with talents an facilities; (3) linkage of researc industry and society; and (4) decisio making machinery and involvemen of people. The effective interactio of research with society is determine neither by opportunities alone nor b the presence of good scientists. Th most significant and critical factor i research leading to socio-economi transformation hinges upon the se ting up of clear goals, charter an objectives of the R and D organisatio and linking them with national an social goals.

Spelling out the needs

Research organisations like the CSIR are often accused of not proving their worth. The main reason for it is simple. Neither the Government nor the industry, in spite of their close association with the

SIR and individual laboratories on
s scientific and executive bodies,
as clearly spelt out its needs and
efined the technology tasks. Can any
ne show where a laboratory has
iled to deliver results when specific
emands are placed on it? In the
bsence of a clear goal and demand,
ow or to what can research be
levant?

For research to be relevant to the
eeds of the people, people should
ell out the needs. Again, which
eople? The small elite conditioned
y Western life-styles? The so-called
rass-roots planning thus becomes
r-conditioned planning. Motor cars,
r conditioners, Coca-cola, etc get
reference over the minimum needs
f the rural people like potable drink-
g water. The person about whose
elfare decisions are being taken is
ot only not involved in the process
ut ignorant about it. And the people
ho take such decisions are often
norant about the rural situation.

The research community is no
etter, either. By training and tem-
erament, and in concept, science is
niversal; researches are undertaken
n currently internationally fashion-
ble areas and researchers get invited
o international conferences. And
nly then the country recognises our
esearchers. All the award, reward
nd incentive systems are loaded in
avour of undertaking such inter-
ationally fashion-oriented research,
lienating the scientific community
nd its work from the people.

It is necessary to popularise science
nd develop a scientific temper and
ttitude of mind if the results of re-
earch are to be absorbed and utilised
y the people. Taboos, rituals and
uperstition must give way to a
ational, open and objective outlook.
People should develop a thirst for
cience and confidence in science.
And confidence can come only if it
an be practically demonstrated that
cience can improve their living and
vorking conditions. This then is the
luty of scientists.

A silent lead in this direction has
een taken by the CSIR in bringing
ut popular science journals in English,
Hindi and Urdu and also funding
ther language journals in science.
Science museums and mobile
nuseums continue to bring science to
eople. Recent ventures like the
"Adoption of District Programme"
re meant to bring science and scien-
ists to the doors of the people, to
dentify their needs and utilise the
echnologies at the grass-roots level.
This has further led to the concept of
lternative technologies and alterna-
ive models of development, aimed at

Padekar

less capital, energy and pollution and more labour-intensive, decentralised production and distribution. A Centre for Science, Technology and Development has been specially set up to understand the interactions and dynamics of science and development. State-wise surveys, discussions with State authorities, industry, State research committees and academics have helped to identify what research organisations can do for the State. A further follow-up is done by a polytechnology clinic set up in the State capital.

The second task is to translate these goals into pragmatic, well-designed, defined and discrete research activities. The most important issue is to take stock of all the phases of the technology spectrum — invention, innovation, design development, transfer and utilisation of technology, economic, social and policy systems. Thus, research should be conceived as one of the social substrata acting and interacting with other social strata and should move (in planning, execution and evaluation) from one set of equilibrium relationship to another until the planned social benefit is realised.

The third phase of optimising social linkage is built on the concept of accountability and recognising the principle that public money is publicly accountable. Scientists readily agree to lay down the scientific objectives and methodologies but hesitate to spell out important parameters such as the social and economic significance of, and resources and time inputs for, their projects. Granted that there are obvious constraints in forecasting estimates of time and resources, an attempt to arrive at an approximation in these areas is a must; as the society — the supplier of investible resources — should be convinced that the pay-off of research is not lower than what is expected from alternative fields of investments. Research being a gamble, even greater care should be exercised in the choice of priority areas of research through input planning. Finally, there should be a task force approach, embracing different disciplines, working as a team to execute the project, and involving the people concerned in the decision-making process.

The CSIR method

What are the criteria for selecting a project at the CSIR? These are mainly based on research relationship to: (1) industrial and economic growth of the country; (2) impact on society or on the common man; (3) breakthrough technologies developed; (4) exploratory or fishing expeditions; and (5) developing indigenous technological competence. The criteria for funding takes into account several factors. These are: (1) certain areas are to be funded entirely by the Government, like running science museums and publication directorates; (2) part or full funding for setting up a new laboratory for infrastructure facilities and for competence-building for a period of five to seven years — of late, the CSIR sets up a laboratory or an extension centre only when the industry and the State concerned pay 50 per cent of the cost; (3) laboratories about 10 years old should attempt to earn 50 per cent of their budget — however, if the laboratory serves mainly the cottage or smallscale sectors like food, leather and glass, the earnings could be less than 50 per cent; (4) Government funding in areas like technological competence-building, basic research for breakthrough technologies, fishing expeditions, etc; (5) funding up to 25 per cent for basic research, 10 per cent for rural development and up to 10 per cent for research in universities are accepted norms; and (6) priority to be given to quick-yielding, people-oriented, multi-disciplined, multi-laboratory and multi-organisational projects.

Despite such a laborious exercise, complaints are still heard that the laboratory research programmes are

not relevant to our needs. How does one plan when the industry and Government do not say what exactly they want? An institutional mechanism is badly needed to identify nationally relevant tasks. Such an exercise was attempted by the National Committee on Science and Technology (NCST). Also, a Technical Committee was set up including the representatives of the Directorate-General of Technical Development, Department of Science and Technology, CSIR, National Research and Development Corporation (NRDC) and the Ministry of Industry to assess technology needs. These endeavours have had only limited success. Thus, a clear policy to develop and use science is yet to emerge.

Having identified the national needs and the technological tasks, these are to be matched with talents and facilities. A multi-disciplinary, multi-laboratory task force is formed, a leader named, and then inputs provided. Such an approach has invariably proved to be a success and the results delivered on time — for example, projects on electronic materials, insecticides, pesticides, scanning microscope, alternative sources of energy, etc. Such an approach also brings about cohesion, a new research culture, team spirit and a sense of achievement.

In a creative research activity, financial control is the only effective control. Polite persuasion and concealed compulsion through financial control are needed to achieve corporate goals and individual laboratory goals. To provide the necessary freedom and flexibility to the individual researcher and yet to bring him into teamwork to achieve a national goal — that is the balance we need.

The technology generated in the laboratory needs to be coupled with design, development engineering skills, economics, and marketing, financial and commercial sense to set up pilot or proving plants. Risk capital is needed for this purpose, and industry is ready to accept only proven technology.

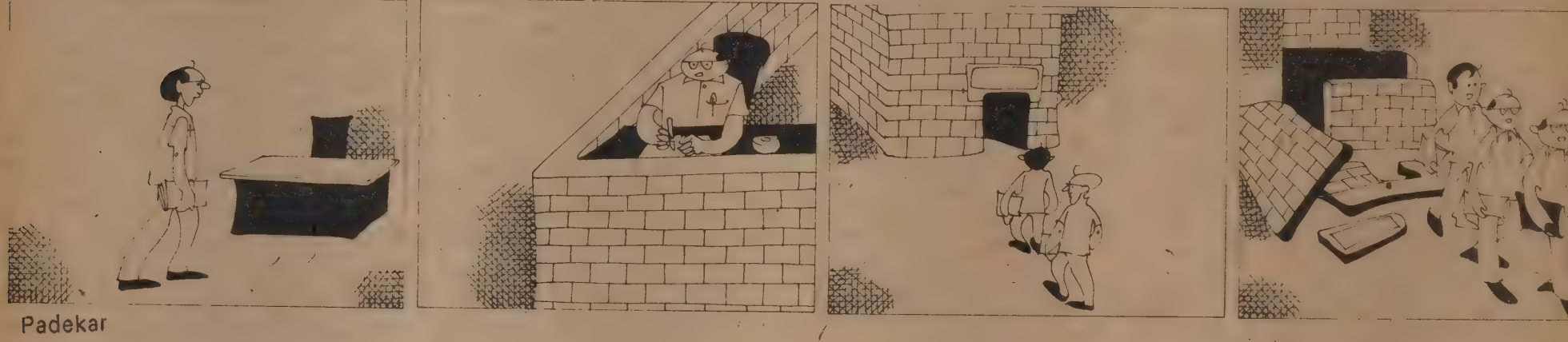
At this point, two choices are open to a research organisation — either to set up its own captive proving plants like the Atomic Energy Commission or, like the CSIR, join hands with other agencies that have the production competence. (CSIR's researches cover a wide spectrum, and it would become a monolithic and highly centralised organisation if it were to have captive plants.) This latter approach has its own limitations; persuading industry is not easy, particularly against foreign competition.

Where there is already internal competence in design, development and engineering — for instance, for oils at the Regional Research Laboratory, Hyderabad, for foods at the Central Food Technological Research Institute, Mysore, and for chemicals at the National Chemical Laboratory, Pune — additional inputs are provided to complement the competence. A step further was taken in the case of civil engineering. The CSIR set up a Civil Engineering Consultancy (CECON) firm of its own to act as consultants to consultancy firms coupling the strength of cement, road, building, structural and environmental engineering research institutes and the National Botanical Gardens, Lucknow. CECON has already paid rich dividends. On the other hand, a research organisation may also draw upon the expertise of engineering consultancy firms, building formal and firm linkages, for example, the Indian Institute of Petroleum + Engineers India Ltd + Indian Oil Corporation; Metallurgical Engineering Consultants + National Metallurgical Laboratory; Engineering Projects India (EPI), etc. EPI, in association with the Regional Research Laboratory, Hyderabad, is setting up a Rs. 130-million low temperature carbonisation plant in Andhra Pradesh.

For the industry to gain confidence in indigenous technologies and to remove the stigma that indigenous technologies are half-baked, technologies are now offered through the NRDC on the following terms: (*i*) on "as is, where is basis" on the condition that the industrialist signs a paper saying that he buys it with open eyes, that he has the capacity to develop and commercialise this l ratory technology, and that he shal complain now or in future; (*ii*) u a secrecy agreement, a consul may prepare a management/inv ment report and on that basis ac or reject the technology; (*iii*) NRDC provides 50 per cent of risk capital for the first proving pl and if it is successful, the party buy back the NRDC share; similarly, NRDC may invest 26 cent of the equity capital in the plant; and (*v*) an engineering sultancy firm coupled with laboratory will give a guarantee warranty, like any other foreign f for setting up a plant based on CSIR's design and technologies any research laboratory anywh in the world is offering better ter one would like to hear from it.

Decision-making system

A laboratory creative and innovative organ



Padekar

tion; its tasks can be accomplish only by creative workers motiva and committed to achievement tasks in time. Involvement of scient down the line is, therefore, essent The vertical hierarchical system m give way to a decentralised, democ tised and internalised collegi system. Decisions should be arrived by debate and discussion and by compulsion. More important is management's awareness of its r and functions, accountability to public and for achievement-audit.

There are two important conside tions in decision-making. One is management information system working out criteria and values a the other, forecasting techniques predict as accurately as possible t effects of different strategies a different constraints. Subject-w technology information centres shou provide information to researche user-industries and to manageme systems. A technical manpower ba helps match the talents with tas A strong technical secretariat to ba up the executive is essential whe planning, programming, monitori and evaluation groups interact wi

oups in technology-utilisation, man-wer, extramural research, inter-tional co-operation in science, ad-inistration and finance. Weekly eetings of an internal committee mprising the chiefs of these groups ll make decision-making easy.

Research is risk. The dynamics of e bureaucratic system based on the inciple of safety, stability and secu-y stifles the risk-taking capacity. hat we need is a venture-oriented, xible system of management, radical attitude and resilient in nature for search and for introducing un-nventional experiments like giving ree-year leave to scientists to set up dustries.

The counter-current flow technique decision-making is another innova-on. Research programmes are final-ed upwards from the bottom of the erarchy and down from the top. ven to prepare guidelines, the cor-orate body first prepares a back-round paper, circulates it to all boratories, inviting comments from e staff and Directors, modifies the aper, which is further discussed at the irectors' conference and a final deci-on is taken thereon. Once a decision taken, that becomes the rule.

Career development and personnel olicies is another important area for volvement. Matters relating to areer opportunities, personnel selec-on, promotions, in-training pro-rammes, and mobility of personnel quire special attention. The staff oncerned must be involved in arriv-g at agreed decisions. Grievance rocedures and joint consultative stems, promotional avenues for uxiliary technical and administrative aff, reducing the number of scales of ay, etc help reduce irritations. pportunities are to be provided for n outstanding scientist to get a irector's salary without being a irector, for a Director to step down nd go back to research; scientists oing to the villages may get the same, not better, reward and promotional venues without publishing in reputed ientific journals; training program-es for personnel in administration, ccounts, materials and research anagement, and information and ex-ension services; technologists coming om abroad given a package deal to t up industries in India, in addition the scientists' pool, supernumerary osts created for scientists and techno-gists coming from abroad; scientists, echnologists and industrialists from oth within and outside the country nvited as visiting scientists, research ssociates, consultants, etc; opportuni-es for scientists to attend seminars nd symposia both in India and broad and also for short- and long-

term training programmes and visits to research and industrial establishments abroad, making use of the international co-operation agreements to supplement our competence and to sell our technologies, and not on the basis of aid or for scientific tourism, etc. All these may involve researchers in the decision-making process and create an atmosphere of trust.

Lack of trust leads to several complications — misunderstanding, caution, rules, reviews, screenings, scrutinies, committees, controls, centralisation, delays, indecision, inaction, suspicion, friction — and affects the morale. It also curbs the initiative and affects the free flow of ideas — so much needed for any successful R and D effort. The management should have the courage to trust and should create an atmosphere of trust. Talking of trust, decision-making by discussion, debate and dialogue involving the people, I may confess that the breaking up of the CSIR structure had come as a bolt from the blue, creating an atmosphere of mistrust. Let me refrain from further comment; it would be improper. The changes are apparently intended to establish stronger links between the technology generator and the user. Whether this required breaking up the CSIR is another matter. CSIR's asset is, in fact, its resilience to change and the internal mechanisms to correct itself. And one often wonders why, among the many research agencies, only the CSIR comes in for experimentation every time. Why is the same yardstick not applied to all?

To conclude, if science has to be developed for the development of people, people must be involved. It is often said, the majority of the rural poor must be brought into the mainstream. Actually, it is the other way round. If the majority are the rural poor, it is the elite that should be brought into the mainstream. The social structure should, therefore, change and the social policy must be directed to create a scientific attitude in people, to bring science to the doors of the people, and to use science as an instrument for social transformation.

Scientists tend to say, "We only know science and produce scientific results, and there it ends; it is for others like the industry and the Government to make good or bad use of it." In my view, this is an escape route designed by clever scientists. If scientists wish to remain in their monastic environment, they should not complain that their bright ideas are not blooming. They should actively interact with the social systems.

All policy decisions are but political and social. It is for the scientific community to provide the decision-making body with technical, economic and rational options open, hoping that the right option is chosen. But is there a scientific community in India in spite of the large number of scientists? Is there an opinion of the scientific community which should be heard with respect by the policy-makers? It is time the scientific community talked with one voice about science, science policy and how it should be integrated with other policies in industry, economics, trade, international relations and education.

Dr. Nayudamma, who was till recently Director-General of the Council of Scientific and Industrial Research, is now Distinguished Scientist at the Central Leather Research Institute, Madras, where he was Director earlier.

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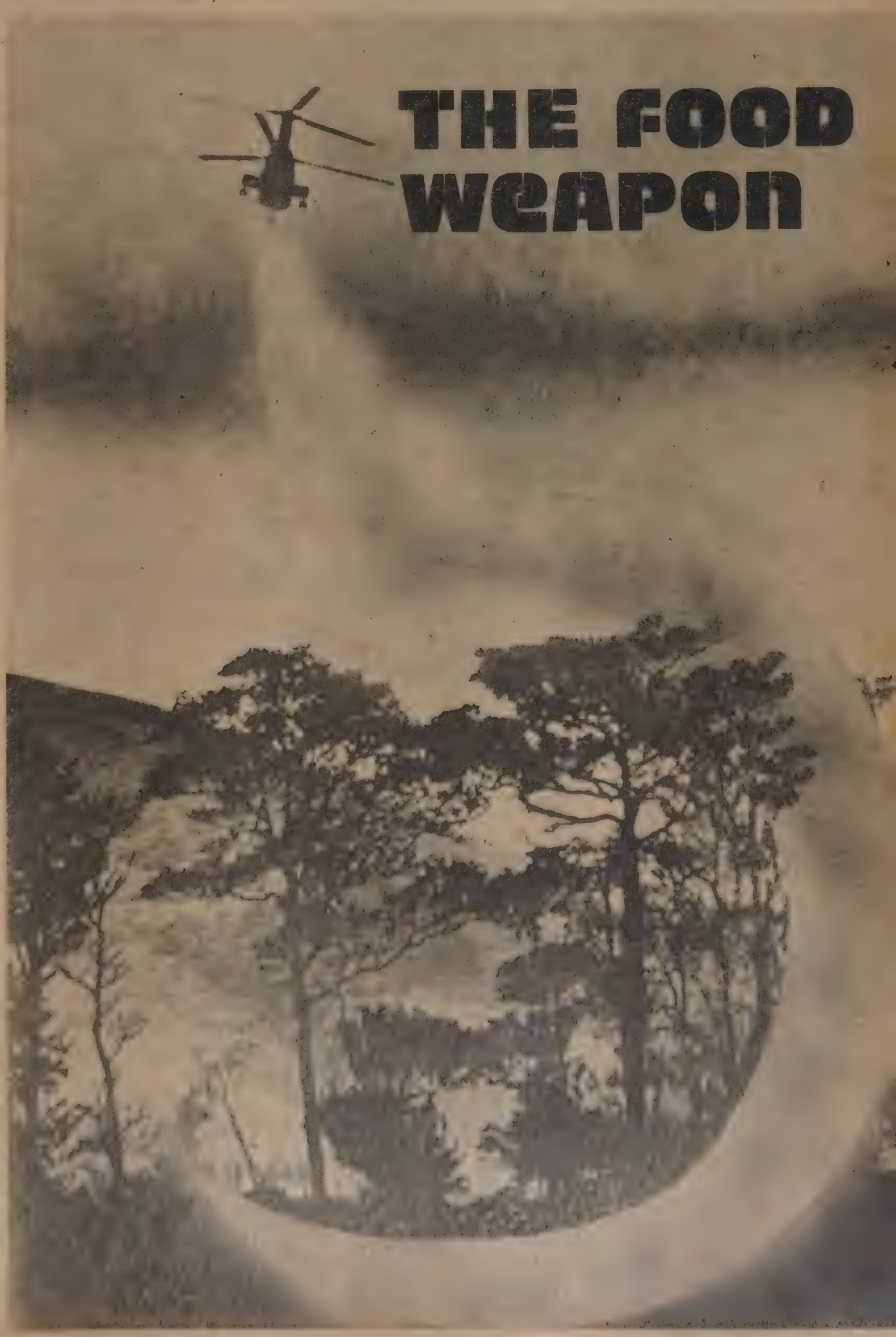
SCIENCE AND SECURITY

The weapons of the future may be, not bombs and bullets, but deadly fungal spores that could wipe out the enemy's standing crops, or chemical agents that could make the soil unfit to bear crops

THE FOOD WEAPON



N. SESHAGIRI

LAST February, four children in Maastricht (The Netherlands) found that the delicious Jaffa (Israel) oranges they had been eating contained small silvery globules of mercury; they were rushed to hospital to have the contents of their stomachs pumped out. Poisoned Israeli oranges were also found in nine West German towns; sales were stopped as orange consignments were hurriedly checked. The metallic mercury was of the kind used in thermometers, and could be quite dangerous to young children. It all appeared to be part of a bid to disrupt Israel's economy, as was claimed in a letter addressed to the West German government by an extremist group.

A more subtle, if indirect, way of using food as a political lever, a weapon, is by restricting its availability to the food-deficient areas of the world. This can be done directly by manipulating the supply of food, and indirectly by using herbicides, defoliants and microbial agents in the enemy's cultivable lands to deny him their use for growing food.

The mounting imbalance between the sources and sinks of food has triggered a new weapon possibility. Before World War II, all the major geographic regions except Western Europe had net surpluses of grain. North America and Eastern Europe were on a par, each exporting around five million tonnes of grain. Asia was producing grain enough to feed its billions. In recent years, however, the picture has changed dramatically. The population of Asia has grown alarmingly, reducing the supercontinent into a net importer of grain on a colossal scale. Each year an average of 50 million tonnes of grain is imported into these regions. Eastern Europe has lost its pre-World War II status as exporter. On the other hand, the North American continent has significantly improved its position, mainly because of its relatively low population density and improved farm mechanisation methods. In spite of significant population growth, North American grain export has doubled from 50 million tonnes in 1970 to 100 million tonnes in 1975.

Typical of current brain-storming among the weapon makers is the article published in the American magazine *Food Policy* (1975). The author, William Schneider of the Hudson Institute (USA), argues that food should be used as a tool of economic warfare. In his evaluation, food is potentially much more effective a weapon than the control of the flow of advanced industrial technology. He argues that " the United States is the only nation able to export agricultural commodities in large quantities that has the parallel capacity to augment the output in changes in world-wide demand. . . . The ability of target nations to substitute indigenous production for imports or to import higher-cost substitutes is extremely limited. The United States has several reasons to use this vast agricultural lever in support of its diplomacy. Many of the nations with which it has conflicts of interest are precisely those whose dependence on US agriculture is likely to be the most significant in the near future. The manner in which the conflicts are resolved is important: they may not be capable of politically acceptable resolution through the use of

force. The agricultural lever, however, may give the environment where it may be difficult to sustain foreign policy objectives by other means". The report of the Office of Political Research (OPR) of the Directorate of Intelligence of the United States concludes that the food weapon "can give the United States a measure of power it never had before — possibly, economic and political dominance greater than that of the immediate post-World War II years".

The superpowers, having realised how easily the power of the food weapon can be employed and controlled, are increasingly endeavouring to realise the capability to upset nature's delicate balance in their favour, aided by a plethora of chemical, biological and geophysical weapons. Of these three components of the food weapon, the geophysical weapon has already been described earlier in SCIENCE TODAY ("The Weather Weapon", July 1976). The more important components, such as chemical weapons and biological weapons, in the context of their use as food weapons, will be briefly outlined here.

Chemical food weapon

At Fort Detrick, Maryland (USA), anti-plant and anti-crop chemicals and biological weapons were conceived, experimented with and perfected for supporting the US armed services in their global military operations. Between 1943 and 1954, over 1,000 chemical herbicides were examined as possible chemical warfare agents. Between 1954 and 1957, another 11,000 chemicals were examined. By the end of 1969, the Fort Detrick Laboratory had screened as many as 26,000 chemical substances as potential agents for destruction of crops and other vegetation. Full-fledged facilities h been known to exist at several ot US institutions. It is also belie that the Soviet Union is at least well equipped in chemical and bio gical armaments as the United Sta The chemical weapon developme in the USSR are known to ha involved such organisations as Institute of Physical Chemistry of USSR Academy of Sciences, Institute of Organometallic Co pounds and certain chemical resea institutes at Kazan.

Scientists at Fort Detrick work out a plan for chemical crop destru tion and forest defoliation in Vietna as part of "Project Agile". Initial they used H-34 helicopters and C-1 cargo aircraft equipped with spec spray systems. Approximately o million hectares of inland forests we subjected to herbicide spraying. T estimates of losses inflicted were per cent of the sprayed area. In ad tion, over 50,000 hectares of mangro forest and about 30,000 hectares Melaleuca woodland were a sprayed. More than 100,000 hectar of cropland were affected by the e of the 1960s. In 1970, the US Depa ment of Defense stated that chemic warfare in Vietnam accounted f damage of more than 10 per cent the entire surface area of Sou Vietnam due to largescale sprayi of anti-plant agents. This correspon to a land area of nearly 20,000 sq k A vegetation-wise break-up of t crop destruction and defoliation this chemical warfare in Vietnam given in Table 1.

TABLE 1. US HERBICIDE SPRAYING IN TH VIETNAM WAR — A BREAK-UP BY VEGETATION TYPE

Weapon category	Vegetation type	Area type (km²
Crop destruction	Paddy rice	2,50
	Field crops	50
	Miscellaneous	4,00
Defoliation	Dense forest	5,80
	Open forest	2,00
	Bamboo forest	80
	Mangrove forest	50
	Rubber plantation	10
	Pine forest	10
	Other forests	1,10

[*Source:* SIPRI's study on the Consequence of the Second Indo-China War]

Anti-plant agents

Anti-plant chemica agents may be categorised, in term of their distinct types of action o plant, into defoliants and desiccants herbicides and soil sterilants. (Th action of the chemical agent als

SPORES, INSTEAD OF BULLETS

HOW can microbial agents be used against standing crops? Let us see what can be done with the fungus *Piricularia oryzae* which causes the virulently destructive disease affecting the rice crops, known as rice blast. The effectiveness of this fungus as a weapon arises from the ease with which it can be grown artificially. The BW agent is the small seed-like spores called "conidia" produced by the fungus during asexual reproduction. Conidia can be easily separated from the main culture of the fungus and with relatively low investment can be stored for considerable period of time.

In nature, these spores get detached from the fungus by air currents and get transported downwind. The conidia can be sprayed from spray tanks of aircraft wherever they are required to be inflicted. The strategy is to map the strength and directions of the wind currents over the enemy territory and fly an aircraft perpendicular to the direction of the wind and spray the conidia in quantities proportional to the velocity of the wind currents. If the enemy territory has a significantly long coastline which is itself perpendicular to the direction of the wind, the appropriate strategy would be to fly the aircraft, just before the harvest season, parallel to the coastline over the international waters or with minimal incursion over the territorial waters and spray the conidia at higher altitudes.

About 2 to 4 grams of conidia will be required per hectare for initiating the primary infection which can destroy about half the rice crops. A proper design of the spraying operation can cause crop loss even as high as 90 per cent. When the primary infection is caused over the rice fields near about the coastline, the infection rapidly spreads inland and downwind. A spore settling on a rice plant germinates and penetrates into the plant, eventually invading the plant tissue all over. From out of the plant tissue, grow the spore-bearing stocks, and the new spores so produced detach themselves and migrate downwind. The propagation potential of *P. oryzae* can be estimated from the fact that a square centimetre of the infected rice leaf tissue can contribute more than 80 million spores.

N.S.

Conidia or spores produced by a fungus during asexual reproduction, seen here breaking loose from the spore-bearing structure (conidiophore)

MAKING THE PACKAGES TINY

STARTING with carbonless copying paper or NCR (no carbon required), the idea of dispensing a useful product in the form of tiny globules, each surrounded by a protective sheath which ruptures under given conditions, has found a host of applications. Micro-encapsulation, as it is called, is now used in the adhesives industry, in packaged foods and drinks, and for liquid crystals.

Carbonless copying paper, first marketed in 1954, is coated on the back with a layer of tiny capsules each containing two separated, colourless leuco dyes (colour-forming materials) dissolved in an organic solvent; each globule has a protective wall and is only a few microns in diameter. The coating is so smooth that it can hardly be detected. This paper is fed into the typewriter, along with a second sheet, the upper surface of which is coated with an undetectable coating of an acidic clay. When the type strikes the paper, the cells rupture under the pressure and the two leuco dyes are released and flow on to the acidic clay of the second sheet. The two dyes produce two separate reactions which result in a print within 30 minutes. A slight variation of this process is to encapsulate the two dyes as before and to coat them along with the acidic clay on to the upper surface only.

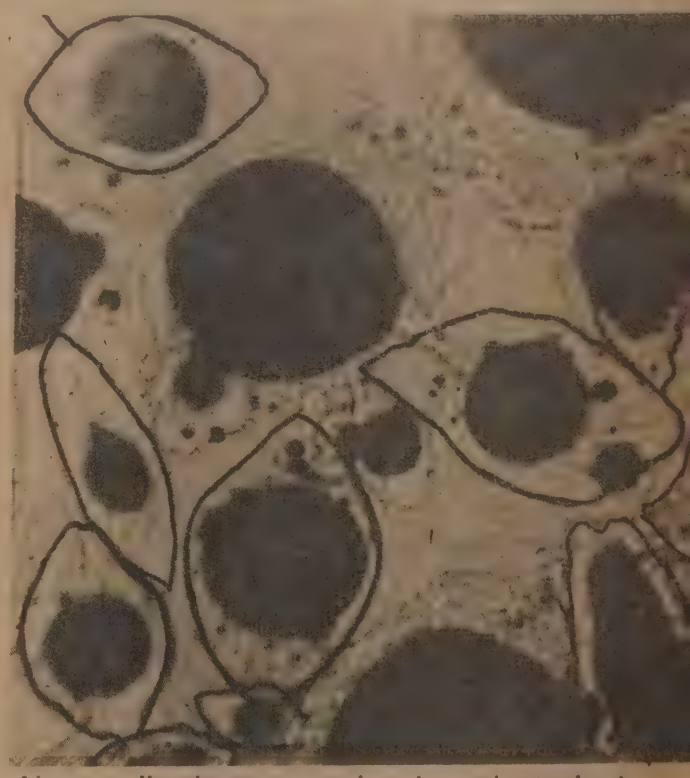
Micro-capsules find their second largest use in the pharmaceuticals industry, to disguise the taste of unpleasant drugs, to release them inside the body over a prolonged period and to enable reactive materials to be mixed together, yet remain separated by the cell walls. Micro-capsules can also be released by heat, and may find a use in wall papers and decorative laminates which will be ironed on without using a separate adhesive. Micro-encapsulation gave a new dimension to advertising some years ago when it was used to print fragrance on to advertising material; unlike old-fashioned perfumed paper, the fragrance remained odourless until the capsules were ruptured.

It is not only solids that can be wrapped up in micro-capsules; even liquids and powders — and hopefully gases — can be so packaged. Fuels like petrol and lithium hydrazide have been micro-encapsulated and then shaped into briquettes; this saves fuel from deteriorating in storage and makes for safety and easy transportation.

Typically, micro-capsules consist of the useful product sealed within a thin-walled spherical sac. Micro-capsules may be made by physical, chemical or 'mechanical' methods. The best known chemical method is coacervation, a technique devised by H. R. Kruyt and H. G. B. de Jong in the 1930s, in which liquid droplets of colloid-rich solution could be made to emerge from a homogeneous solution of various polymeric materials. The droplets while coming out of the solution could be made to enclose any minute insoluble particles that may be in the solution. The result is a suspension of micro-capsules. Micro-capsules have been even made around fine fibres.

The walls of micro-capsules are mostly made of natural or synthetic polymers, but waxes, resins, glasses and metals may be used. The walls can be made rigid or flexible and its relative porosity to diffusion of liquids and gases can be controlled with great precision. Once the capsules are made, they can be dried to a free floating powder, used as a slurry in liquid, moulded into bricks, pressed into tablets, coated on to a substrate or used in any other way which doesn't damage them.

P.K.



Almost all microencapsulated products look like this under the microscope. The encapsulated material, in this case a liquid, appears as golden orange spheres, each sealed within a transparent capsule wall of basically ellipsoidal form

depends upon the mode of application and the type of vegetation that is attacked.) In defoliation, the main objective is to remove the foliage without necessarily killing the plants — by a chemical interference with the mechanism that brings about the seasonal shedding of leaves. In plants that do not shed their leaves, it would be necessary to ensure chemical means for the drying of leaves. Such chemicals are called desiccants.

The second distinct type of action is to poison the plant to death with chemicals called herbicides. The third distinct type of action is to prevent the growth or regrowth of plants by chemical sterilisation of the soil in which they may grow. Such chemicals are called soil sterilants.

A list of successful anti-plant agents employed by the United States in Vietnam for crop and forest destruction is given in Table 2 (see also SCIENCE TODAY, February 1972, p. 43).

TABLE 2. STANDARDISED AGENTS USED BY THE USA IN CROP AND FOREST DESTRUCTION IN INDO-CHINA

Military name of agent	Chemical components	Weight proportion (kg per gallon)	Military utility
Agent Purple	N-butyl, 2, 4-D (acetate) N-butyl 2, 4, 5-T (acetate) Iso-butyl 2, 4, 5-I (acetate)	2·40 1·25 0·85	General purpose anti-plant agents useful for destruction of broad-leaved crops like banana and defoliation of forests
Agent Orange	N-butyl 2, 4-D (acetate) N-butyl 2, 4, 5-T (acetate)	2·4 2·4	
Agent White	Tri-isopropanolammomium 2, 4-D Tri-isopropanolammomium picloram	1·7 0·4	Used for longer term forest defoliation
Agent Blue	Sodium dimethularsinate cacodylic acid	1·56 0·06	Effective for destroying rice crops

[*Source*: US Department of Army, Circular TC3-16, and study by H. B House *et al.* of Mid-west Research Institute, USA]

The microbial offensive

In the 1969 Report of the Secretary-General of the United Nations concerning the chemical and bacteriological weapons and the effects of their possible use, it is stated that for a largescale operation against a civilian population, destruction per square kilometre might cost about $2,000 with conventional weapons, $800 with nuclear weapons, $600 with chemical weapons and only $1 with biological weapons. Before the 1970s, almost all known species of pathogenic micro-organisms affecting staple crops had been examined in biological warfare (BW) laboratories. From

A BONUS FROM DEFOLIANT SPRAYING?

Vietnam's exposure to war was undoubtedly unique, and now Vietnamese scientists are becoming increasingly worried about the war's possible hangovers. Apart from the probably permanent rearranging of its landscape by bomb craters, and the effects on flora and fauna caused by the bombardment, the use of chemical agents against the vegetation might have had some kickbacks that even the users didn't bargain for, such as, effects on humans.

It was in 1969 that the US Department of Health, Education and Welfare published reports that 2, 4, 5-T, one of the components of the chemical agent "Orange" used in Vietnam, was teratogenic in rats and mice. An independent report later revealed that commercial preparations of 2, 4, 5-T contained a highly toxic contaminant, dioxin (2, 3, 7, 8-tetrachlorodibenzo-p-dioxin) which even at microgram levels was teratogenic in experimental animals. Sample stocks of agent "Orange" retrieved from Vietnam revealed dioxin in concentrations of 0·05-47 ppm. On the basis of these figures it has been estimated that at least 100 kg of dioxin were dropped on Vietnam.

A Vietnamese cytologist, Dr. Bach Quoc Tuyen, according to a report in *Nature* (16 February 1978), claims that the incidence of chromosomal abnormalities in people exposed to 2, 4, 5-T and its dioxin contaminant in Vietnam was higher than expected. Tuyen's finding has been criticised on the ground that the sample studied was too small, and that he has reported as abnormal a level of chromosomal abnormalities — breaks and gaps — which would be considered normal in the West. Tuyen feels it is important to confirm two earlier reports by American scientists. One report (1972) states that there was a marked increase in the incidence of still births in one province. The second by Arthur Westing, reporting to the Swedish Academy of Scientists in February 1977, speaks of an increase in the rate of spina bifida and cleft palate in a Saigon hospital from 1966-68, the years of the heaviest spraying programmes.

Another Vietnamese scientist, Prof. Tung suggests that dioxin may be responsible for an increase in primary carcinoma of the liver in Vietnam, but he is not too sure. Western scientists point out that there is a remarkably short time between the deposition of dioxin — beginning in 1962 — and the appearance of liver tumours. Most known carcinogens have a latency period of 20-30 years.

P.K.

these experiments have emerged the most effective viruses, bacteria and fungi that can attack and destroy most of the staple food crop strains; besides, their methods of delivery to the target area are also well understood.

Viruses are the smallest living organisms which can only grow as parasites in the cells of other living organisms. They consist mainly of strands of nucleic acid covered by protein. Bacteria, on the other hand, are single-celled organisms of size ranging from less than one micron to a few tens of microns and do not ordinarily require living cells for their growth. Fungi are single- or multi-celled plant-like organisms with cells ranging from 3 to 15 microns in size (1 micron = 1/1000 mm). Some of the more potent viruses, bacteria and fungi identified to be highly potent BW agents for destroying staple food crops are given in Table 3.

TABLE 3. POTENT MICROBIAL AGENTS FOR DESTROYING STAPLE CROPS

Disease	Causative Agent
	Viruses
Tobacco mosaic	
Sugar beet curly-top	
Corn stung	
Hoja blanca (rice)	
Fiji disease (sugarcane)	
Potato yellow dwarf	
	Bacteria
Rice blight	*Xanthomonas oryzae*
Corn blight	*Pseudomonas alboprecipitans*
Sugarcane wilt (gumming disease)	*Xanthomas vasculorum*
	Fungi
Late blight of potato	*Phytophthora infestans*
Coffee rust	*Homileia vastatrix*
Maize rust	*Puccinia polysora*
Powdery mildew of cereals	*Erysiphe graminis*
Black stem rust of cereals	*Puccinia graminis*
Rice brown-spot disease	*Helminthosporium oryzae*
Rice blast	*Piricularia oryzae*
Stripe rust of cereals	*Puccinia glumarum*

[*Source :* SIPRI and Ambio, *Vol. IV*, Nos. 5-6, 1975]

Delivery systems

Increase of infectivity presupposes purity of the agent payload. The concentration and purification of microbial cultures has been perfected for peaceful applications like the production of vaccines and in biological pest control. A recent break-through has been achieved by the US Atomic Energy Commission and the US Department of Agriculture through a technique called 'zonal centrifugation' in which micro-encapsulated concentrated doses of the agent within the residual culture tissue are obtained in addition to their becoming highly weather-resistant. At Fort Detrick, a chemical extraction centrifugation technique and an ultra-filtration and precipitation technique have been developed which can produce the agent in 99 per cent purity.

The micro-encapsulation technique (see box on p. 51) which has become popular with civil and military scientists, has revolutionised biological warfare. Here the BW agent is dispensed in the form of tiny globules, each protected by an envelope which makes it resistant to weather extremes and ultraviolet radiation and enables it to withstand the rigours of dissemination over great distances in concentrated and pure form, making it violently contagious. Double-wall micro-encapsulation has also been developed for better protection of the agent; even if the outer impermeable membrane melts away, the permeable, pathogen-containing micro capsule would still be deposited safely on the target. These agents which were discounted earlier as weapons on account of the high fragility of the infectious nucleic acids of the BW agent, which are highly unstable in air, may now be moulded into bizarre weapons. With anti-crop agents like the spores of *Bacillus antiasis* and *Puccinia graminis*, serious crop losses can be inflicted even as far as 900 km down wind. Aerial spraying techniques combined with micro-encapsulation can use the wind to carry the BW agent across a country's border or coastline, provided, of course, that wind direction remains stable over a number of days.

Even though all the nations have signed the UN Convention banning the use of chemical and biological weapons for any purpose including crop destruction, it is clear now that the superpowers have increased rather than decreased their research and development efforts for developing more potent chemical and biological weapons. The hypocrisy of disarmament, coupled with the fact that there is no economically feasible counter-measure against the chemical and biological food weapons, adds urgency to the need for the mobilisation of moral forces and enlightened public opinion by constantly exposing the plans and projects of the superpowers and making people more aware concerning the potentialities of such weapons.

[This article is based on the author's book, *The Food Weapon*, to be published by The National Book Trust of India in June 1978.]

ow Do Tornadoes Occur?

TORNADOES are violently rotating, funnel-shaped atmospheric disturbances. Their exact uses are still not perfectly understood. They are normally associated ith intensive depressions, hurricanes large cumulo-nimbus (thunder) ouds.

A tornado is usually visible as a nnel-shaped cloud. It is seen to iginate at the base of a cloud and adually move down to earth, taperg off at the surface. A tornado funnel ay retract from or drop to the round several times during its travel, aving intermittent trails of damage. he funnel cloud may be deflected by e wind. Several funnel clouds may tend downwards at the same time om a vigorous storm cloud.

Lightning accompanies tornadoes. ut there is still doubt whether lightng is the result of the tornado or plays some important role in ausing tornadoes.

Wind direction in tornadoes usually llows the rules for depressions and yclones, that is, it is anti-clockwise in e northern hemisphere and clockise in the southern hemisphere

SCIENCE TODAY, January 1978, p. 53). he wind speed is difficult to measure ecause an ordinary anemometer annot withstand the force. In one ecorded case, that of a tornado which assed over El Dorado, Kansas, USA, June 1958, the wind speed was ound to be 331 kmph; the actual peed may be twice as much. The verage speed of a tornado may be aken as 60 kmph.

The destructive portion of a tornado ay vary in diameter from 1 metre to ,500 metres. For instance, the Coochehar tornado of 19 April 1963, and e Diamond Harbour tornado of 1 March 1969, had destructive iameters of 100 to 130 m, and 30 to 00 m, respectively. The destructions hey caused were very localised, as appened in Delhi recently.

Tornadoes vary in the distance hey travel. On 26 May 1917, a ornado travelled 471 km over Texas, JSA. In contrast, a tornado at Wyoming, USA, in 1954 ran only 15 m. However, a tornado at Dakota, USA, emained stationary over a place or 45 minutes.

As mentioned earlier, tornadoes lways form in association with severe hunderstorms. Vertically, these hunderstorms penetrate the tropopause (the boundary between the troposphere and the stratosphere, at a height of about 15 to 17 km from the surface of the earth). Exchange of air occurs between the troposphere and the stratosphere under such circumstances, and this exchange leads to an increase in the radioactivity in the troposphere in the area where the tornado is formed. In fact, an increase in radioactivity was observed in the recent tornado at Delhi.

How do tornadoes actually cause destruction? There are several ways. The first is by the direct impact of wind (the force being proportional to the square of the wind speed). A wind speed of 350 kmph can hit an object with a force of 700 kg/m². Second, within the narrow band in which it circulates, the tornado moves with unequal speeds. This causes a twisting motion. For instance, winds blowing in a tornado of a small cross-section are often of so much greater force on one side of a tree than the other that they saw off the tree-top. The third means is by explosion, which results when a tornado passes directly over an area which is at normal atmospheric pressure. The barometric pressure in a tornado has not been measured, but a narrow tornado may have a gradient of 60 millibars. This difference in pressure may cause an explosion; roofs may be sucked off and walls may explode outwards. In the USA, tornado safety rules advise that windows and doors on opposite sides of a building be kept open to equalise the pressure. The fourth means is by lift and drop. An updraught of 240 kmph was indicated in a film taken of a tornado at Dallas, USA, on 2 April 1957. Such strong currents can lift and throw off things and also human beings. At Delhi, even a bus loaded with passengers was lifted and thrown into a ditch.

Tornadoes occur all over the world. The US experiences the maximum—an average of 700 tornadoes a year

(Contd. on p. 57)

The profile of an incipient tornado as it begins to bulge away from the cloud base (below, left), taper and descend towards the ground (bottom, left). The tornado then elongates, taking on a funnel shape and a spin, and lashes out (below, right). This tornado hit across an open land in Kansas, USA, in May 1970. The pictures were taken by two highway policemen who first spotted the bulging cloud

Biogas systems—the Asian experience

BIOGAS SYSTEMS IN ASIA by S. K. Subramanian, Management Development Institute, New Delhi, 146 pp, Rs. 25

THE book is a report of a survey undertaken in India (funded by the Council of Scientific and Industrial Research) and in other Asian countries (funded by the International Development Research Center, Canada). The author, a former secretary of the National Committee on Science and Technology, has tried to encompass every phase of biogas work briefly. Apparently, single-handed, he has collected more information than an ICAR (Indian Council of Agricultural Research) committee, which toured the country to evaluate the economics of the gobar gas plant two years ago. The ICAR Committee was probably preoccupied with proving that the (long defunct) IARI (Indian Agricultural Research Institute) plant is cheaper than the KVIC (Khadi and Village Industries Commission) plant.

Though the process of anaerobic digestion of organic waste is not fully understood, the main factors affecting its economic exploitation are well established. And designers have successfully utilised these factors. All designs broadly fall into two main categories — one, with the digester and the gas holder in a single unit and the other, with these in two separate units. A third design has come up in recent years, which uses a masonry digester closed at the top, without a gas holder, collecting gas in the upper part by replacing the slurry. The plant has been used in China. I may mention that Mr. G. S. N. Moorthy of Bangalore had put up a small plant of this kind in 1966. Neoprene bags (Taiwan) have also been used as biogas plants. Rectangular digesters with similar gas holders have been used in the Republic of Korea and several Pacific countries. These have now been replaced with circular ones.

User families value the gobar gas plant most for the clean gas it gives. But some find the digested slurry of greater value as organic fertiliser. A school reports that Para and Napier grasses required to be replanted every three years when urea was used, but when digested slurry from the gobar gas plant was used, the grasses were found in their prime even in the fifth year after planting. A farmer reports that he reclaimed a plot which he now uses for growing sugarcane. Root crops fertilised with digested slurry weighed three times more than those grown in the normal way in adjoining plots. Surprisingly, an isolated report from the IARI states that fresh, liquid, digested slurry had an adverse effect on wheat and one other crop, compared to farmyard manure and other fertilisers in pot experiments. I may add that Mr. Ghosh of the IARI had stated at the ESCAP workshop on biogas technology and utilisation that in trial plots, repeated use of fresh digested slurry increased the basic productivity every year. Since the digested slurry loses almost all its ammoniacal nitrogen on drying, as well as most of its soil-improving benefits when used for composting other agricultural wastes, more studies are necessary to reap the full benefits of these reported results, especially because digestion in a biogas plant retains all the nitrogen in the original dung, gives more fertiliser out of the raw materials than by any other method, removes all weed seeds and does not attract termites which damage field crops. I have a strong feeling that the fine particle size of the digested slurry has much to do with its advantages.

Biogas is mainly used for cooking in all countries. In India, gas from a plant at the Tulsishyam Temple, Junagadh District, Gujarat, has been consistently used for power generation for the last ten years. The use of biogas in engines in India is also increasing. There is some doubt about the per capita gas requirement for cooking. The usual estimate is 198 to 425 litres of gas per person per day, but the author suggests 172 to 198 litres. I may add that the consumption was 340 litres when town gas burners were used. The IARI reports 425 litres with cheap shoe polish tin and cigarette tin burners developed by them, and it is 198 litres with the gobar gas burners (55 to 60 per cent efficiency) developed by the KVIC. Despite the largescale use of high-efficiency burners, the author stresses the need for developing better burners. However, even the most developed LP gas burners for family kitchens have the same efficiency as those of the KVIC. It must also be stated that in providing for roasting of unleavened *rotis*, some efficiency loss does occur. Community kitchens, especially in cooking involving boiling, use much less gas. My experience shows a great need to train women in villages to properly use the hig efficiency burners now in comm use.

Some countries, notably Taiwa have started an integrated use of t digested pig dung slurry for growi algae and fish, before its final use fertiliser. So far, this has not be found feasible with cattle dung slur because of the difficulty of physica separating clear liquid from the sludg Even if this is done, integrated use possible in this country only aft community plants are installed at t village level.

Though cattle dung digestion in th country and pig dung digestion in t Asian and Pacific countries are main practised, it is digestion of agricultur wastes and nightsoil that has receiv attention in India and China. Tow garbage and industrial wastes have r ceived attention in Japan. Work do in China in nightsoil digestion in ki ing parasite eggs shows that the phys cal separation of these eggs is the be way to kill them. Since the India biogas plant is designed to remove th digested slurry from the top of th digester, the danger of the presence parasite eggs in the digested slur may be expected to be minimun Besides, pathogen-killing also depen on the length of digestion. Whi in most cases, a 30-day period woul be enough, Indian plants use a dige tion period of 50 to 60 days.

It is rather disappointing that th book has nothing to say on the role the biogas system in preventing rura pollution and fly-breeding. This one of the three major aims, alon with producing energy and organi fertiliser, of adopting biogas in India villages.

Of the two major factors affectin anaerobic digestion — mixing th slurry during digestion and tempera ture — the latter seems to be greater importance. So far, neithe heating nor mixing is used in th family plants anywhere to any exten Of the mesophilic and thermophili range of temperatures, the forme seems to be more practical. In report ing the claims made by teams workin in the field, the author has not tried t evaluate them. Hence, there is danger of the lay readers acceptin the claims. The Gobargas Researc Institute at Ajitmal claims that 90 cm × 122 cm flat-plate sola collector delivers 1·5 litres of wate at 60°C every minute in the winter which is several times more than wha can be obtained during the hottes hour in the summer. Its othe

im of obtaining three times more
e quantity of gas from solar-heated
gester than from unheated digester
nounts to a conversion of 70 per
nt of the dry solids of dung into gas
weight — a miracle! That the
at is efficiently transferred to the
derground digester by thermo-
hon from a flat-plate collector
ced at a height on the surface is
o open to serious doubt.

Some other claims reported in the
ok need further explanation. Like
one made by a college in South
dia about cooking by biogas.
ore details are also needed
understand how the methane-
cteria culture helps in promoting
ter digestion in view of the fact
t conversion of cellulose to acids
the limiting factor in anaerobic
gestion involving all wastes except
htsoil and city sewage, and not
methane formation — a fact ad-
tted by the author himself.

A number of institutions are busy with the National Committee on Science and Technology-co-ordinated research programme on biogas in its various phases — heating the digester with solar energy, study of fermentation kinetics, alternative materials of construction, power generation, etc. Several countries are active in biogas research. The amazing list of more than 50 lines of research suggested by the author probably includes every topic concerning biogas research. Fermentation kinetics and development of more efficient burners are emphasised.

The present gobar gas systems in India benefit only the well-to-do farmers, due to both design and financial constraints. Banks are cautious in approving loans and, therefore, take such a long time that the client loses interest by the time the loan is sanctioned. And the prices estimated by the KVIC, on which subsidies and loans are regulated, are much lower than the actuals in almost all cases. A cheap plant for the small farmer and community plants at the village levels should, therefore, form the basis of our future programmes, though several constraints, especially social, in community plant programmes will have to be faced.

Finally, the book seems to have been written in a hurry. At some places, one can't understand what the author wants to convey. For instance: "It is possible to increase loading further by two or three times, if the concentration of digester sludge is made over 10 volume per cent." Besides, there are numerous printing errors, normally not expected in a publication from an institute devoted to the development of better management. A subject index would have been greatly useful. On the whole, the book is timely and worth the effort.

JASHBHAI J. PATEL

[Mr. Patel was for long consultant to the Khadi and Village Industries Commission on gobar gas plants.]

UESTION & ANSWER

ntd. from p. 55)

s reported during the last decade;
er a thousand were killed in
nadoes in the same period in the
SA. In India, they occur mainly
March and April. West Bengal,
sam, Tripura and Bangla Desh are
e areas most prone to tornadoes.
eports of severe thunderstorms are
ard every year, particularly from
baishakhis in West Bengal; many of them may be due to tornadoes. Last year, on 1 April, a tornado near Dacca killed 500 people and injured 6,000.

A tornado can be expressed in terms of the Torro scale used in the UK. It is based on the extent of the damage caused. On this scale, the Delhi tornado was of the value 6. Generally, tornadoes in India and Bangla Desh may go up to 9. In the USA, the average strong tornado is 9 and the strongest recorded is 11. The highest figure on the scale is 12.

Since its lifespan and the aerial extent are small, it is not possible to forecast a tornado. From the weather charts, a forecaster may predict thunderstorm and/or hailstorm but not a tornado. Some attempts have been made with radar. If a tornado is detected from radar observations, a warning can be issued, but since the tornado lifespan is of the order of minutes, the warning will always be late.

Over north-west India, some disturbances in the weather often come from the west and cause rain and thunderstorms. They are prominent during winter and spring. On the morning of 17 March 1978, a prominent "western depression" was located to the west of Delhi which was likely to cause thunderstorms over vast areas of west UP, Haryana, Punjab and adjacent places. The wind shear in the upper air was very strong (see Table). Analysing several cases of hailstorms, D. V. Rao and A. K. Mukherjee had earlier concluded (*Indian Journal of Meteorology and Geophysics*, **9**, 1958) that when thunderstorms form in the field of strong vertical wind shear, they tend to become severe, and large hailstorms fall from them.

Upper wind at Delhi and Patiala at 5-30 am (IST) on 17 March 1978

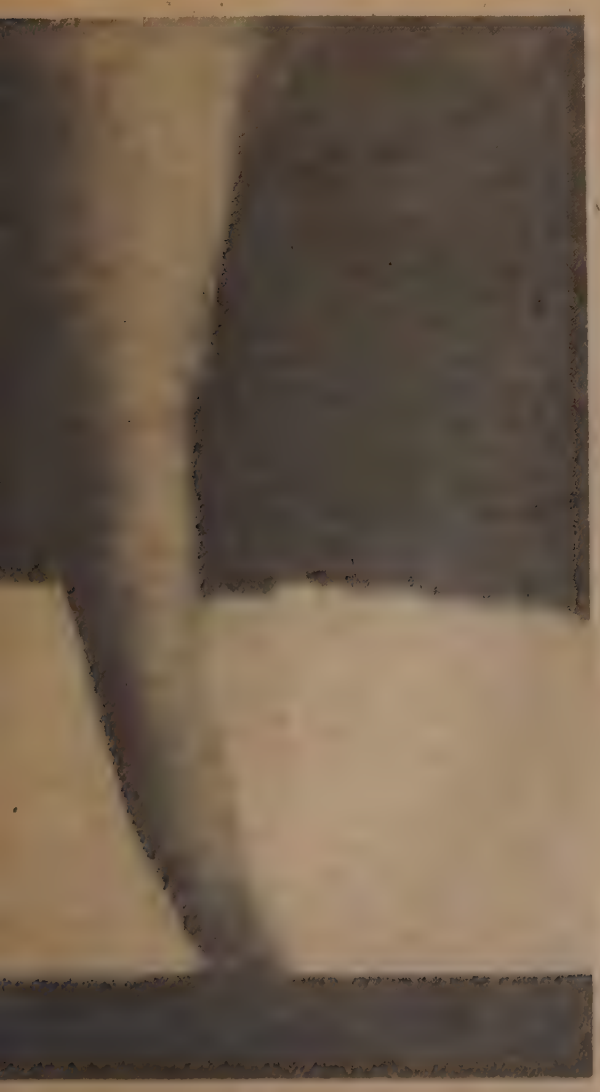
Pressure level	Approx. height	Winds at (direction in degrees and speed in knots, respectively)	
		Patiala	Delhi
850 mb	1·5 km	135°, 35	180°, 10
700 mb	3 km	250°, 40	250°, 50
500 mb	5·8 km	270°, 30	230°, 40
300 mb	9 km	250°, 85	230°, 100
250 mb	10·5 km	230°, 105	240°, 115

The condition near Delhi on the morning of 17 March was just right to cause a severe thunderstorm and hail over Delhi and the neighbouring areas. The meteorological department could, therefore, forecast a severe thunderstorm and hailstorm. The same conditions sometimes lead to the development of tornadoes. In the present case, a tornado developed and was noted because of the damages it caused over the crowded areas. There might have been other, similar tornadoes at other places in the region on this day. The severe damage reported from Mussouri on the same day appears to have been caused by another tornado.

A. K. MUKHERJEE

[Dr. Mukherjee is Director of the Regional Meteorological Centre, Bombay.]

other tornado that hit Kansas in 1929



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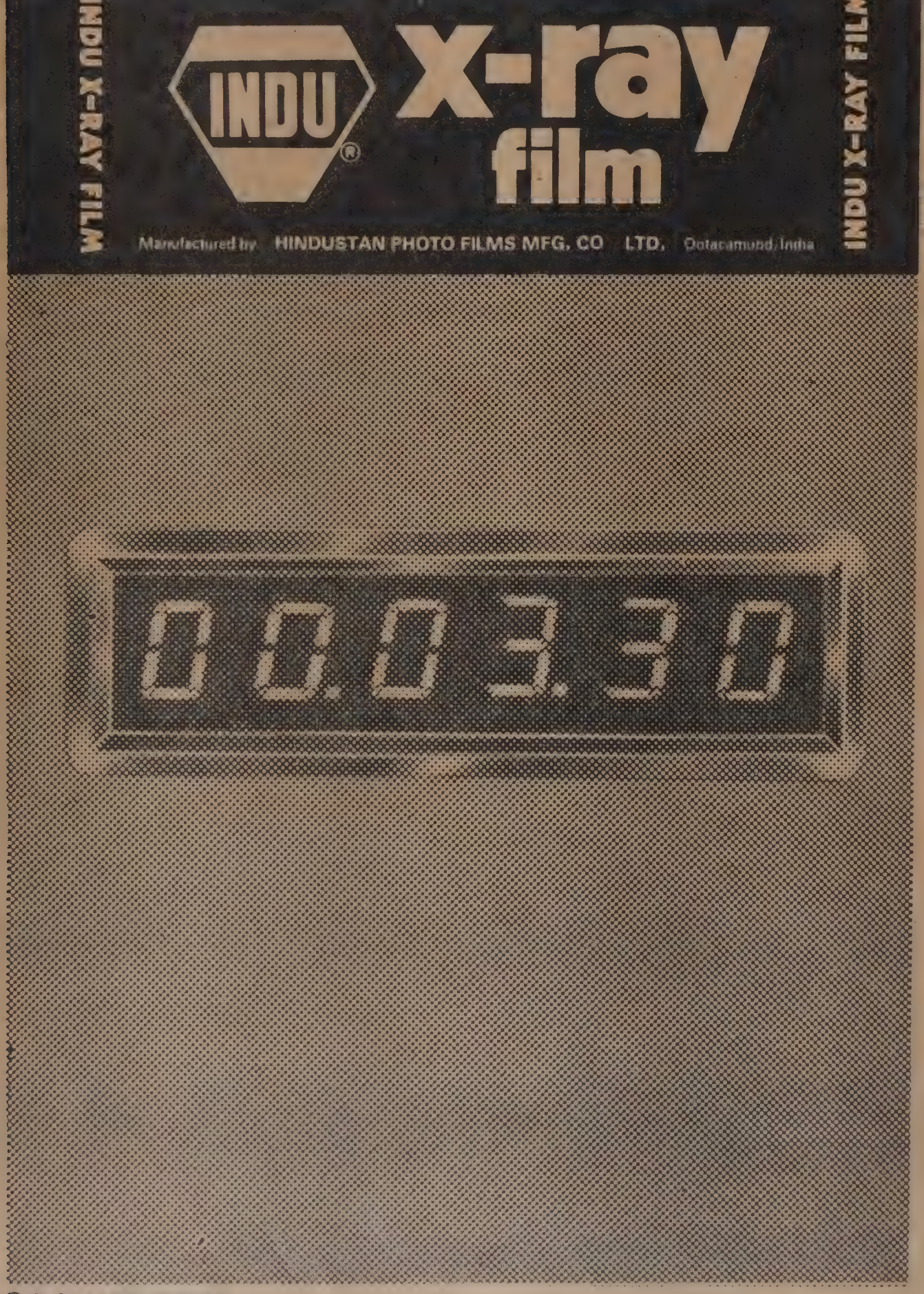

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DELAY SWITCH FOR CAR ROOF-LIGHT

THIS is a fully solid-state device extremely useful for motor car drivers at night. This device can be fitted on any motor car having 12 volts positive or negative earth system.

The roof-light of a car can be lighted by opening either of the two front doors or by operating the roof-light switch. Normally, on the hinged side of each front door, closed push-type switches, called door switches, are fitted and wired in parallel with the roof-light switch. Thus, while the roof-light switch is in OFF position, the roof-light remains OFF as long as one or both the front doors are closed. When one of the front doors is opened, the respective door switch gets closed and the roof-light lights up. The delay switch, when fitted in the roof-light circuit of a motor car does not allow the roof-light to go OFF immediately the door is closed. It gradually reduces the light intensity and only after 10 to 15 seconds does the light go completely OFF. Thus, you get light for sufficient time to insert the ignition key, start the engine and switch on the panel lights if required.

The circuit of the device requires few electronic components and is extremely simple to assemble. The collector-emitter connections of the Darlington pair transistors are wired across one of the door switches of a car. This has to be done with proper polarity, depending upon the positive or negative ground system of a car. When the door is opened, the door switch closes its contacts and the collector-emitter circuit of the Darlington pair gets shorted through the contacts and the 250 mfd timing capacitor gets immediately discharged through the diode BY 125 and the 100 ohm resistor path. When the door is closed, though the door switch immediately opens its contacts, the collector-emitter path of the Darlington pair transistor remains in conduction till the timing capacitor charges through the 10K resistor in series with it. The diode BY 125 and 100 ohm resistor in series with it cannot contribute to the charging because of the unidirectional characteristics of the diode BY 125. While the capacitor builds up the charge, the voltage across the 10K charging resistor drops. When the capacitor charges to about 70 per cent of the full charge value, the drop across the 10K charging resistor cannot supply the necessary input current to the Darlington pair to keep it in conduction and the roof-light gradually switches off. When the capacitor gets fully charged, neither the capacitor nor the Darlington pair draws any current through the car battery till the door is opened and closed again.

When the door is opened and closed, the full current required by the roof-light is eventually drawn through the transistor 2N3055. Thus, if the wattage of the roof-light lamp is more than 6 watts, then the transistor has to be fitted on a suitable heat sink or aluminium plate of 10 cm × 10 cm. The heat sink or the aluminium plate has to be electrically isolated from the rest of the circuit as well as the car chassis. This way, you can operate a lamp up to about 25 watts.

The diagram below shows connections of the device for cars having negative earth system. In cars having positive earth system these connection sequences are reversed, ie, the positive of the unit (collector of 2N3055) is connected to the chassis side of the door switch and vice versa.

You will need:

Semiconductors

Transistors: 2N3055 or 2N6253 or 2N6371, 1 no.; SL100 or 2N3053 or 2N1481 or BEL N100, 1 no. *Diodes:* B4125 or B4126, 1 no.

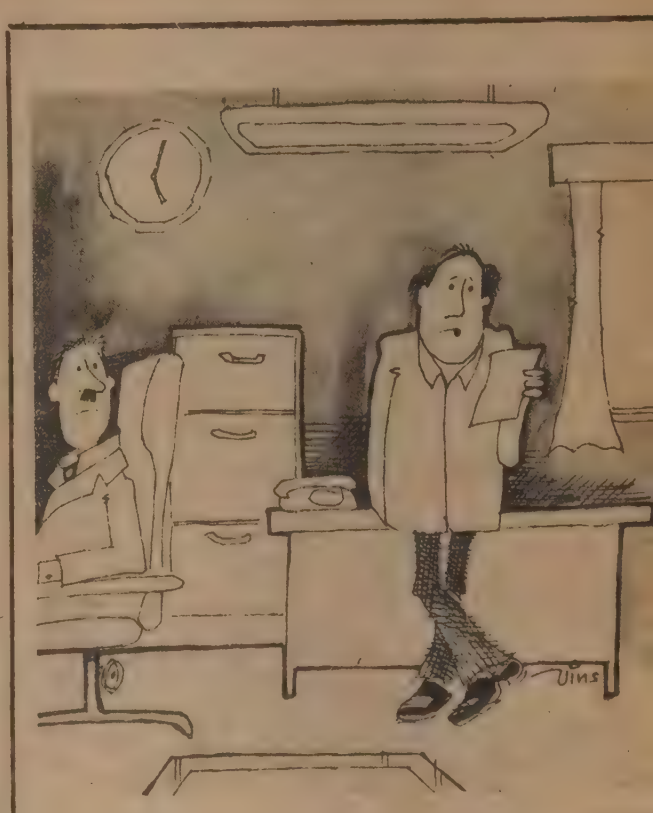
Capacitor (electrolytic): 250 mfd, 25V, 1 no.

Resistors (all ½ watt type): 10K, 2 nos.; 100 ohms, 1 no.

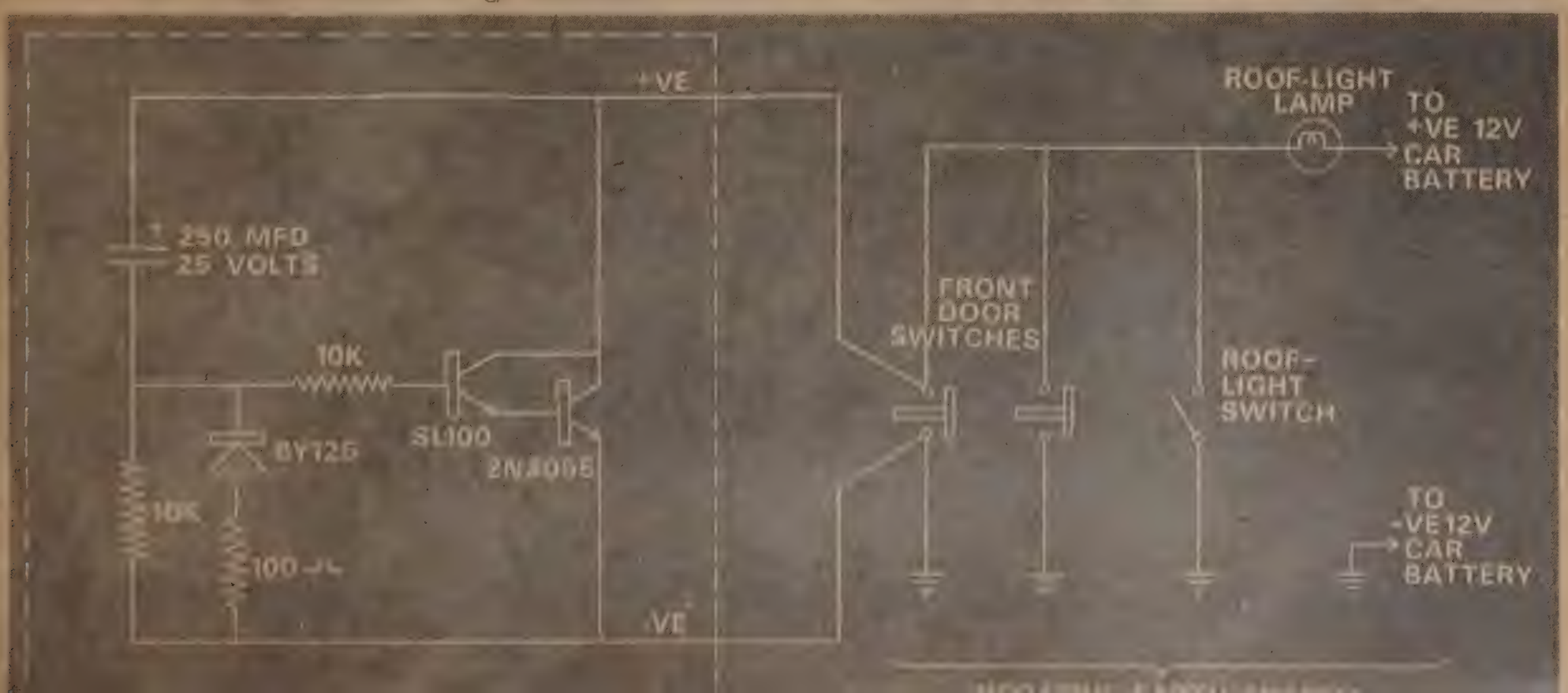
(The price of the above electronic components is Rs. 25.)

Misc: Heat sink or aluminium plate 10 × 10 cm, wires, solder, screws, etc.

ANIL V. BORKAR



"Now the ornithologists want to organise a farewell party for the migratory birds."



HINDUSTAN LEVER RESEARCH FOUNDATION (HLRF)

RESEARCH GRANTS FOR 1978

Applications are invited for HLRF Research Grants for the year 1978, for research work in the fields of Agriculture (including processing of Agricultural products), Animal Husbandry and Industrial Chemicals.

Only scientists engaged in scientific research, pertaining to any of the above fields, in the extension of knowledge or in adoption of findings of Research in Indian rural sectors and working in an institution/university approved under Section 35 (1) (ii) of the Income Tax Act, 1961, are eligible for the grant.

Requests for application form may be sent to the Secretary, Hindustan Lever Research Foundation, Chakala, Andheri East, Bombay 400 093.

The last date for receiving the application is 31st May 1978.

AWARDS & APPOINTMENTS

Sarabhai Research awards

Five scientists have been selected for the Dr. Vikram Sarabhai Research Awards for 1977. The awardees are: Electronics & Telecommunications: O. P. N. Calla, Chairman of Communication Area, Space Application Centre, Ahmedabad; Planetary and Space Physics: Dr. Bimla Buti, Physical Research Laboratory, Ahmedabad; Atmospheric Physics and Hydrology: P. V. Joseph, Meteorologist, India Meteorological Department, New Delhi; Systems Analysis and Management Problems: Prof. K. S. Parikh, Indian Statistical Institute, New Delhi, and Prof. A. G. Sarma, School of Automation and Department of Aeronautical Engineering, Indian Institute of Science, Bangalore.

OTAI award

S. D. Thirumala Rao, Director, Oil Technological Research Institute, Anantapur, Andhra Pradesh, has been awarded the Oil Technological Association of India's Gold Medal for 1977 for his contribution to the oil and oil-based industry.

Dr. Rao and his colleagues, G. Azeemoddin, D. Atchyuta Ramayya and G. Kristappa, have won the Prag Narain Memorial Award for 1977 for their best project report " Industrial Recovery of Lecithin from Oilsludges ". Lecithin is used in a variety of industries like bakery, chocolates, ice creams, surface coatings, printing inks, leather, defence stores, etc.

BC Roy awards

Ten medical men have been awarded the Dr. B. C. Roy Awards for 1977 for their work in various branches of medical science. They are: Dr. Atm Prakash, Head of the Department of Surgery, All-India Institute of Medical Sciences, Dr. K. V. Thiruvengadam, Professor of Medicine, Madras Medical College, Madras, Dr. M. P. Mehrotra, Head of the Post-graduate Department of Medicine, S. N. Medical College, Agra, and Dr. S. S. Anand, Emeritus Professor of Surgery and former Director, Post-graduate Institute of Medical Education and Research, Chandigarh, in the category of medical teachers; Dr. P. M. Udani, Director-Professor, Institute of Child Health, J. J. Group of Hospitals and Grant Medical College, Bombay, Dr. C. L. Pathak, Head of the Department of Physiology, Biophysics and Biochemistry, S. N. Medical College, Jodhpur, and Dr. U. K. Sheth, Head of the Department of Pharmacology, Seth G. S. Medical College and KEM Hospital, Bombay, for work in developing various specialities; and Dr. P. C. Bhatia and Dr. Ramniklal R. Doshi, Honorary Secretary, Blind Relief and Health Association, Chibhodara, Kaira district, Gujarat, win the award in the category of socio-medical relief. Dr. B. C. Roy " oration " award has been given to Dr. C. K. Jayarama Panicker, Director and Professor of Microbiology, Medical College, Calicut.

ROUND-UP OF RESEARCH *(Contd. from p. 24)*

regions of the asteroidal belt (where there are evidences for the existence of such objects) and must have been captured by Mars. However, the circular orbit still remains a mystery and a probable answer may be that Mars may have had an extended atmosphere which could turn an initially eccentric orbit into a circular one due to the atmospheric drag; the primitive atmosphere must have been lost after the orbit circularisation. Protogeological evidence of Mars also points to the possible presence of a thick atmosphere in the past.

Other observations indicate that Phobos possesses a regolith (a layer of dust and rocks). This is made possible due to the ejected material (during an impact of meteorites) being trapped in a stable orbit around Mars which could have been swept up later by Phobos giving rise to the regolith.

V. S. VENKATAVARADAN

[Dr. Venkatavaradan is with the Cosmic Ray and Solar Physics Group, Tata Institute of Fundamental Research, Bombay.]

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Hawkins pressure cooking gives your family healthier food than ordinary cooking, because it seals in more nutritional value. A survey of extant scientific literature by the Central Food and Technological Research Institute has shown that certain nutritive elements, particularly vitamins and proteins, are better retained in pressure cooking.

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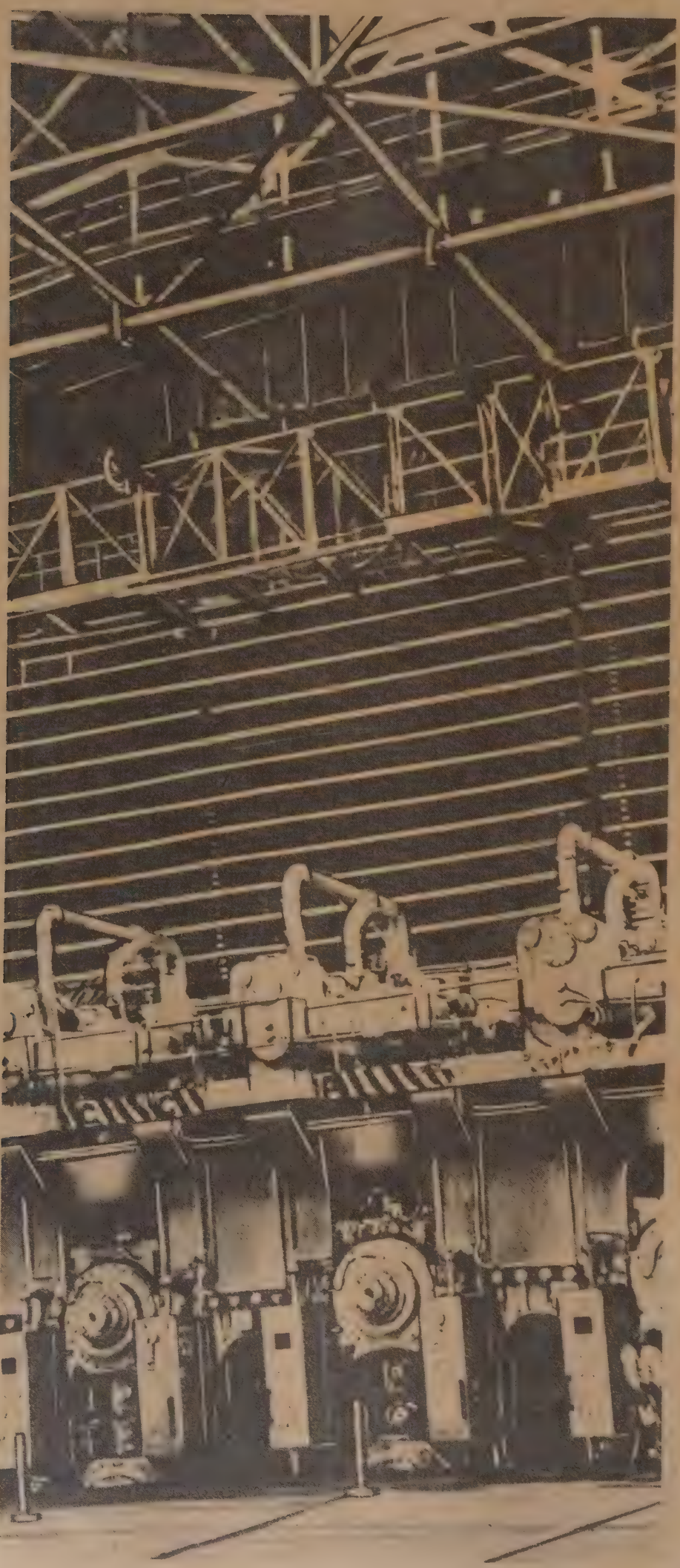
The 'roll' in steel proves the point



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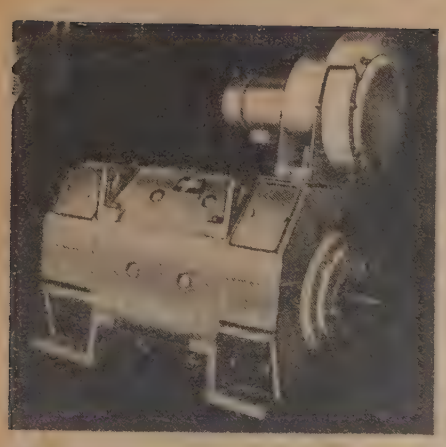

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